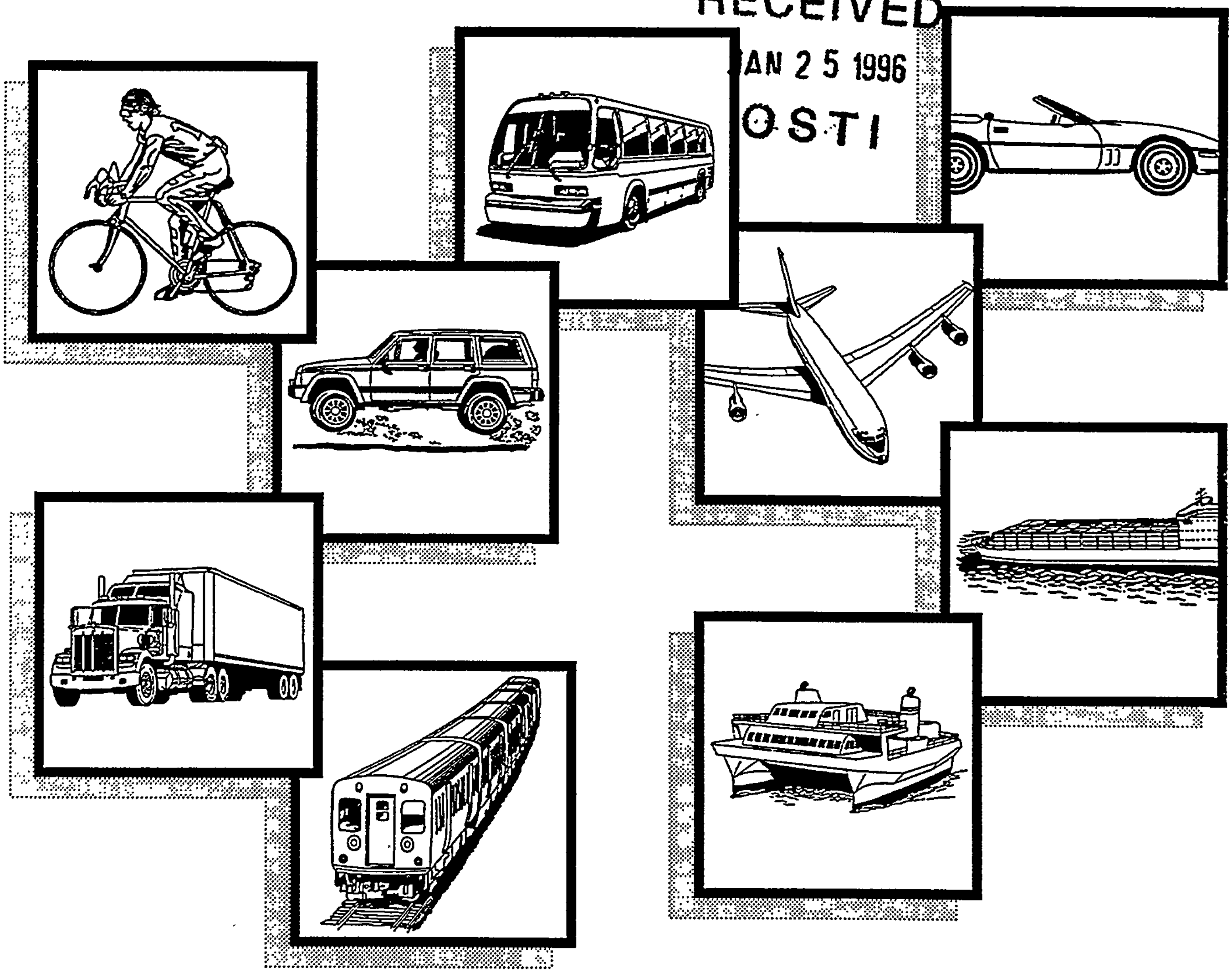
TRANSPORTATION ENERGY STRATEGY

Project #5 of the Hawaii Energy Strategy Development Program



August 1995

Prepared by
PARSONS BRINCKERHOFF QUADE & DOUGLAS, INC.

In Association with
ACUREX ENVIRONMENTAL
and
HAWAII NATURAL ENERGY INSTITUTE

Submitted to
THE ENERGY DIVISION
STATE OF HAWAII DEPARTMENT OF BUSINESS, ECONOMIC DEVELOPMENT, AND TOURISM

DOE/SF/19168--T15

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Project #5 of the Hawaii Energy Strategy Development Program

Prepared for

State of Hawaii

Department of Business, Economic Development, and Tourism

Energy Division

by

Parsons Brinckerhoff Quade & Douglas, Inc.

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Acurex Environmental Corporation

and

Hawaii Natural Energy Institute

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Transportation energy strategy; project #5 of Hawaii Energy Strategy Development Program. Prepared for State of Hawaii Department of Business, Economic Development and Tourism Energy Division by Parsons Brinckerhoff Quade & Douglas, Inc. in association with Acurex Environmental Corporation and Hawaii Natural Energy Institute. Honolulu: Energy Division, Dept. of Business, Economic Development and Tourism, State of Hawaii, 1995.

1. Transportation-Energy conservation-Hawaii. 2. Fuel switching-Hawaii.
I. Acurex Environmental Corporation. II. Hawaii natural Energy Institute.
HD9502.H3.H47.1995

ACKNOWLEDGMENTS

The authors would like to express their appreciation to the many individuals and organizations who contributed to this project.

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ACRONYMS

ac	acre
AC	alternating current
AEC	Acurex Environmental Corporation
AFV	alternative fuel vehicle
ALS	Area Licensing Scheme
AMFA	Alternative Motor Fuels Act
AMOCO	American Oil Company
ANL	Argonne National Laboratory
API	American Petroleum Institute
APSC	Arizona Public Service Company
APU	auxiliary power unit
ARPA	Advanced Research Projects Agency
ASTM	American Society for Testing and Materials
ATIS	Advanced Traveler Information Systems
ATMS	Advanced Traffic Management Systems
AVCS	Advanced Vehicle Control Systems
bbl	barrels
BHPPAR	BHP Petroleum Americas Refining, Inc.
BTUs	British Thermal Units
C&C	City & County
CAA	Clean Air Act
CAAA	Clean Air Act Amendments
CAFE	corporate average fuel economy
CARB	California Air Resources Board
CBD	Central Business District
CEC	California Energy Commission
CIP	Capital Improvement Project
CMAQ	Congestion Mitigation and Air Quality Improvement
CNG	compressed natural gas
CO	carbon monoxide
CO_2	carbon dioxide
COFA	Canadian Oxygenated Fuels Association
CVO	Commercial Vehicle Operations
DAGS	Hawaii State Department of Accounting and General Services
DBEDT	Hawaii State Department of Business, Economic Development & Tourism
DC	direct current
DDC	Detroit Diesel Corporation
DOD	United States Department of Defense
DOE	United States Department of Energy
DOT	Hawaii State Department of Transportation
DSEP	Dual-shaft Electric Propulsion
DTS	City and County of Honolulu Department of Transportation Services

E#	(% Ethanol)
EIA	Energy Information Administration
EIS	Environmental Impact Statement
EO	Executive Order of the President of the United States
EPA	Environmental Protection Agency
EPRI	Electric Power Research Institute
EPACT	National Energy Policy Act of 1992
ETBE	Ethyl Tertiary Butyl Ether
EV	electric vehicle
FAA	Federal Aviation Administration
FEIS	Final Environmental Impact Statement
FFVs	fuel flexible vehicles
FHWA	Federal Highway Administration
FMVSS	Federal Motor Vehicle Safety Standards
FOB	free-on-board
FTA	Federal Transit Authority
FY	fiscal year
gal	gallon
GASCO	The Gas Company
GEG	gasoline equivalent gallon
GM	General Motors
gpy	gallons per year
GRH	Guaranteed Ride Home
GSA	General Services Administration
GVW	gross vehicle weight
HART	Honolulu Area Rapid Transit
HC&S Co.	Hawaiian Commercial and Sugar Company, Inc.
HD	Harbors Division
HDVs	heavy duty vehicles
HECO	Hawaiian Electric Company
HEI	Hawaiian Electric Industries, Inc.
HELCO	Hawaii Electric & Light Co., Inc.
HEP	Hawaii Energy Policy
HES-5	Hawaii Energy Strategy #5
HEVDP	Hawaii Electric Vehicle Demonstration Program
HFFC	Hawaii Fueling Facilities Corporation
HHC	Hawaiian Homes Commission
HHV	Higher Heating Value
HNEI	Hawaii Natural Energy Institute
HOV	high occupancy vehicle
hp	horsepower
H-POWER	Honolulu Project of Waste Energy Recovery
HPTA	Honolulu Public Transit Authority
HRT	Honolulu Rapid Transit
HSPA	Hawaiian Sugar Planters' Association
IC	internal combustion
ICE	internal combustion engine
IDSEP	Improved Dual Shaft Electric Propulsion
IGCC	Integrated Gasification Combined Cycle

IPP	independent power producers
ISTEA	Integrated Surface Transportation Efficiency Act
IVHS	intelligent vehicle/highway systems
J	joules (1 Btu = 1055 joules)
kWh	kiloWatt-hour
LDVs	light duty vehicles
LEBU	large-eddy breakup
LEV	low emission vehicle
LNG	liquefied natural gas
LOS	level of service
LOTMA	Leeward Oahu Transportation Management Association
LPG	liquefied petroleum gas
M#	(% Methanol)
MECO	Maui Electric Company
MEO	Maui Economic Opportunity, Inc.
mgpy	million gallons per year
MIS	management and information system
mpg	miles per gallon
MSW	municipal solid waste
MTA	Mass Transportation Agency
MTBE	methyl tertiary butyl ether
MW	Megawatts
N/A	not applicable
NG	natural gas
NOx	nitrogen oxides
NRC	National Research Council
NREL	National Renewable Energy Laboratory
O&M	operation and maintenance
OEM	original equipment manufacturers
OMPO	Oahu Metropolitan Planning Organization
ORNL	Oak Ridge National Laboratory
OTA	Office of Technology Assessment, United States Congress
OTEC	Ocean Thermal Energy Conversion
PICHTR	Pacific International Center for High Technology Research
POD	pedestrian-oriented development
POL	petroleum-oil-lubricants
PUC	primary urban center
QA/QC	quality assurance/quality control
RDD	research, development and demonstration programs
RTP	Regional Transportation Plan
RUL	regular unleaded gasoline
RVP	Reid vapor pressure
SAE	Society of Automotive Engineers
SCA	South Coast Air
SCAQMD	South Coast Air Quality Management District
SCE	Southern California Edison
SDOT	State Department of Transportation

SMPG	seat-miles per gallon
SNG	synthetic natural gas
SOV	single occupant vehicles
SRIC	short-rotation, intensive-culture
SVMC	Specialty Vehicle Manufacturing Corporation
TAME	tertiary amyl ethyl ether
TBA	tertiary butyl alcohol
TCMs	transportation control measures
TDM	transportation demand management
TMA	Transportation Management Association
TRO	trip reduction ordinance
TSM	transportation systems management
U.S.	United States
U.S.DOE	United States Department of Energy
U.S.DOT	United States Department of Transportation
UH	University of Hawaii
USABC	United States Advanced Battery Consortium
USDA	United States Department of Agriculture
v/c	volume to capacity ratio
VHT	vehicle hours traveled
VMT	vehicle miles traveled
WTC	World Trade Center
ZEV	zero emission vehicle

1 hectare (ha) = 2.471 acres
1 acre (ac) = .0405 hectare

EXECUTIVE SUMMARY

PROJECT PURPOSE

This study was prepared for the State Department of Business, Economic Development and Tourism (DBEDT) as part of the Hawaii Energy Strategy program. Authority and responsibility for energy planning activities, such as the Hawaii Energy Strategy, rests with the State Energy Resources Coordinator, who is the Director of DBEDT.

Hawaii Energy Strategy Study No. 5, Transportation Energy Strategy Development, was prepared to:

- collect and synthesize information on the present and future use of energy in Hawaii's transportation sector;
- examine the potential of energy conservation to affect future energy demand;
- analyze the possibility of satisfying a portion of the state's future transportation energy demand through alternative fuels; and
- recommend a program targeting energy use in the state's transportation sector to help achieve state goals.

The analyses and conclusions of this report should be assessed in relation to the other Hawaii Energy Strategy Studies in developing a comprehensive state energy program.

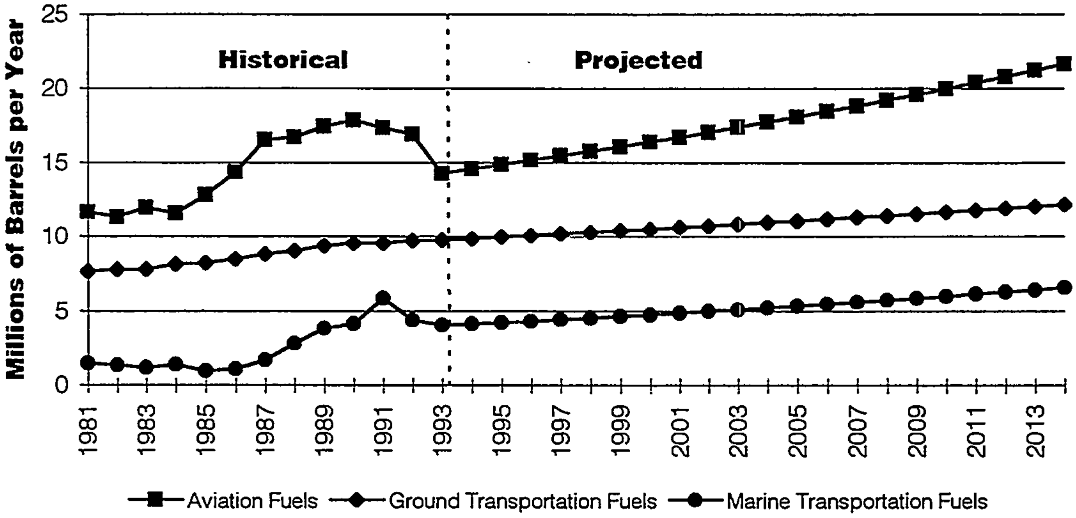
CURRENT AND FUTURE ENERGY USE IN THE TRANSPORTATION SECTOR

Chapter 2 profiles recent energy use in the state's ground, air and marine transportation sectors. The amount of fuel consumed by all sectors combined increased from about 20.7 million barrels in 1981 to about 31.5 million barrels in 1990, a compounded annual rate of increase over that period of approximately 4.29 percent. Since 1990, however, energy use has decreased in the aviation sector and grown only slowly in the ground sector. Total annual consumption in 1992 was 31.0 million barrels, a 0.8 percent decrease from 1990.

In 1992, Hawaii 's transportation sector consumed 62 percent of the petroleum and 55 percent of the total energy used in the state. Of the three transportation sectors, air transportation consistently consumes the most energy by a substantial margin, representing over 50 percent of the transportation sector's total energy demand.

Based on existing transportation plans, energy use in the state's transportation sector is projected to increase at an annual average rate of 1.75 percent between 1993 and 2014, increasing the state's already large dependence on imported oil. Historical and projected transportation fuel use are shown in Figure 1. This projection serves as the basis to examine the potential for energy conservation and petroleum displacement by alternative fuels.

Figure 1.
Transportation Fuel Sales Volumes by End Use, 1981-2014



The state has little opportunity to affect energy usage in the air and marine sectors, but could potentially have a significant influence on energy usage in the ground sector. With the ground sector representing 20 percent of the petroleum consumed in the state in 1992, and with ground sector energy demand projected to increase at a 1.05 percent annual rate between 1993 and 2014, the ground sector represents a sufficiently large component of the state's total energy demand to be worthy of attention.

THE POTENTIAL OF CONSERVATION

Chapter 3 focuses on the effectiveness of energy conservation measures applicable to the ground transportation sector. Measures that improve the average efficiency of vehicles used in the state (miles per gallon) would have a powerful effect on energy demand, and large enough increases in efficiency would reduce energy demand without altering travel behavior, lifestyle or land use development patterns.

In addition, the amount of energy "wasted" due to roadway congestion is appreciable. Estimates based on transportation modeling approaches indicate that ground sector fuel demand could be reduced by around ten percent if measures to eliminate congestion were implemented.

Changes in travel behavior and land use development patterns could also reduce future energy demands below projected levels. Chapter 3 describes 28 transportation system management measures, including changes in land use development patterns, and concludes that the transportation system management measures with the greatest potential for reducing transportation energy demand are:

- expansion of public transit;
- high occupancy vehicle (HOV) facilities;
- automobile use limitations;
- transportation management associations;
- actions by educational institutions; and
- energy-efficient land use patterns.

PETROLEUM DISPLACEMENT

Even with conservation measures, petroleum demand is projected to continue to increase. The displacement of a significant portion of petroleum use in the ground transportation sector by locally-produced alternative fuels could, with a properly designed implementation program, help reduce demand for petroleum-based fuels and thereby achieve both energy security and economic stimulus goals.

Because of the benefits of petroleum substitution, the relatively higher price of petroleum products in Hawaii compared to the mainland, the availability of waste and renewable resources with the potential for production of alcohol and electricity, an agricultural infrastructure capable of conversion to energy crops, and climate and geography which provide a good match with the characteristics of EVs, Hawaii has a foundation at least as strong as any other state on which to begin a program to achieve substantial petroleum displacement in the ground transportation sector.

An aggressive program involving mandates and subsidies could displace 22 percent of the petroleum used in the state's ground transportation sector by 2014. This level of displacement is consistent with national goals. More aggressive petroleum substitution would be limited by the rate at which vehicles capable of using alternative fuels could be introduced, and the time required to establish alternative fuel production and distribution systems. Less aggressive substitution would defer the benefits of substitution.

CANDIDATE ALTERNATIVE FUELS

Chapter 4 introduces the alternative fuels most frequently proposed to replace gasoline and diesel in the ground transportation sector, reviews government efforts to support alternative fuels, and presents possible Hawaii-specific scenarios for substituting petroleum with alternative fuels. This study addresses the following alternative fuels: alcohols (methanol and ethanol), natural gas, propane, electricity, biodiesels and hydrogen. Technologies to utilize alternative fuels is either well-developed or developing rapidly, and Hawaii has had previous and ongoing experience with most of them.

The National Energy Policy Act of 1992 (EPACT) requires the use of alternative fuels in steadily increasing numbers of light duty vehicles, beginning with federal fleet vehicles in 1994, state and fuel provider fleet vehicles in 1996, and private and municipal fleets as early as 1999.

It may not be appropriate to pursue all of the alternative fuels, however. In Chapter 5, the fuels are screened in relation to their potential contribution to a set of strategic and near-term considerations.

The analysis in Chapter 5 concludes that electric energy and alcohol have the potential to provide more benefits than the other alternative fuels. While propane has and is expected to gain increasing market share through public and private sector efforts, it is tightly linked to the petroleum market and therefore does not satisfy the energy security criterion as well as alcohol and electricity. Biodiesel satisfies the strategic criteria, but encounters a large price penalty. Hydrogen powered vehicles have been built, but they are not expected to be commercially available soon. Natural gas fails to meet the criteria listed above because, among other shortcomings, it is not available in Hawaii and the only locally available gas is synthetic natural gas, which has not been proven as a usable fuel with commercially-available internal combustion engines.

INFRASTRUCTURE REQUIREMENTS

Chapter 6 describes the existing gasoline and diesel distribution infrastructure and some of the implications on fuel distribution infrastructure that would be associated with implementing alternative fuels programs.

Storing, distributing and marketing biodiesel and propane for use in motor vehicles in Hawaii would be relatively uncomplicated. Biodiesel blends can use the existing diesel distribution infrastructure, provided the seals and other components which are made of rubber are compatible with biodiesels. The necessary propane infrastructure already exists and can be expanded as needed.

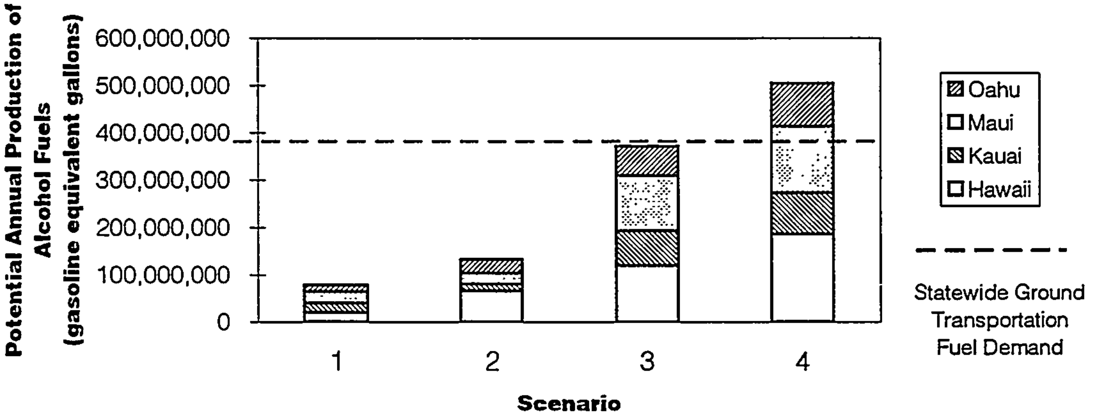
Low-level alcohol blends can use the existing gasoline retail structure as they do in other states where fuel blending is common. Infrastructure for neat alcohols and high-level alcohol blends is not in place, and use of such fuels would require properly engineered bulk storage facilities and refueling station systems, as well as appropriate methods of truck and barge transfer of the alcohol fuel.

Electric vehicle (EV) infrastructure is in place in the sense that electric utilities serve the islands and most people have electric service. Additional EV-related infrastructure would include charging stations at residences, public locations, and businesses, and battery recycling and disposal facilities. Utilities would need to assess the impact of increasing numbers of EVs on their systems; while off-peak charging of EVs could provide operational benefits to utilities and therefore should be encouraged, on-peak charging should be avoided.

POTENTIAL FOR LOCAL PRODUCTION OF ALTERNATIVE FUELS

The potential for local production of alternative fuels is presented in Chapter 7. Several scenarios for large-scale energy crops and alternative ground transportation fuel production were considered, including: 1) use of agricultural byproducts and organic wastes; 2) use of only those lands (or equivalent lands) taken out of intensive cultivation during the past 25 years (approximately 100,000 acres); 3) conversion of all lands presently in intensive cultivation (nearly 230,000 acres) to energy crop production; and 4) use of those lands (or equivalent lands) presently and previously (25 years ago) in intensive agriculture (nearly 330,000 acres). Selected results of these scenarios are shown in Figure 2.

Figure 2.
Potential Transportation Energy Production in Hawaii from Energy Crops, Agriculture Residues, and Wastes



COSTS

Chapter 8 presents an analysis of the costs that would be associated with alternative fuel use in the ground transportation sector. Costs span a wide range depending on the particular alternative fuel, the feedstock, the scale of production, the nature and pace of technological improvements, whether the fuel would be produced locally or imported, and if locally produced, whether fuel production would occur on the same island as fuel use. Cost projections in this chapter are retail, "at the pump" amounts which include infrastructure, shipping cost, and tax components. Overall, given current technology, prices and taxes, alternative fuels, other than low-level ethanol blends, are more costly than gasoline. (It should be noted, however, that gasoline and diesel are themselves subsidized fuels.)

Long-range, large volume alcohol production scenarios suggest that high-level alcohol blends (M85 and E85) could provide energy at costs only slightly higher than current prices for gasoline and diesel, although near-term, low volume scenarios show that alcohol costs could be substantially higher than present gasoline and diesel prices. The projected costs of biomass-derived alcohols are primarily influenced by feedstock price, processing cost, plant scale, and, in scenarios which include barging between islands, shipping and terminal-related costs.

Fuel taxes are another important element in projected fuel costs at the pump. Under current State and County fuel tax laws, motor fuels are taxed on a per-gallon basis. This puts most alternative fuels at a disadvantage on a cost-per-mile basis, since alternative fuel vehicles use more gallons to travel the same distance. Revising fuel taxes to be based on energy content would remove a disincentive to the use of alternative fuels while preserving current levels of tax revenue.

For some applications, propane is competitive with gasoline now. For fleet use of propane, the main cost element is the vehicle conversion cost. For non-fleet use of propane, the high price of retail propane is one inhibiting factor.

For electric vehicles, the most significant cost element is the cost of the vehicles. A variety of technologies, manufacturers and prices are currently available, but the rapid pace of development in this area makes a comparative cost estimation for EVs difficult. If EV purchase costs could be reduced, EVs could become very cost-competitive in the marketplace.

If the benefits of alternative fuels can be shown to justify the costs of an alternative fuel program, government action may be warranted. Chapter 9 examines measures the state could take, ranging from the least intrusive (the support of research and development) to the most intrusive (government provision of fuel). Some of the measures require the state to commit to a particular fuel type and alternative energy program, while other measures, such as adjustment of fuel taxes to reflect the lower energy content of alternative fuels, reduce existing barriers without promoting any particular fuel.

IMPACT AND EFFECTIVENESS OF POTENTIAL ALTERNATIVE FUEL PROGRAMS

In Chapter 10, potential measures to increase the use of alternative fuels are evaluated in terms of achieving long-term objectives of energy security, environmental sustainability and local economic stimulus. Measures to encourage the use of alternative fuels are generally intended to reduce or eliminate barriers to alternative fuel vehicle (AFV) adoption, such as the lack of infrastructure, fuel availability and cost, and consumer acceptance. Actual benefits and costs are difficult to quantify and have many uncertainties.

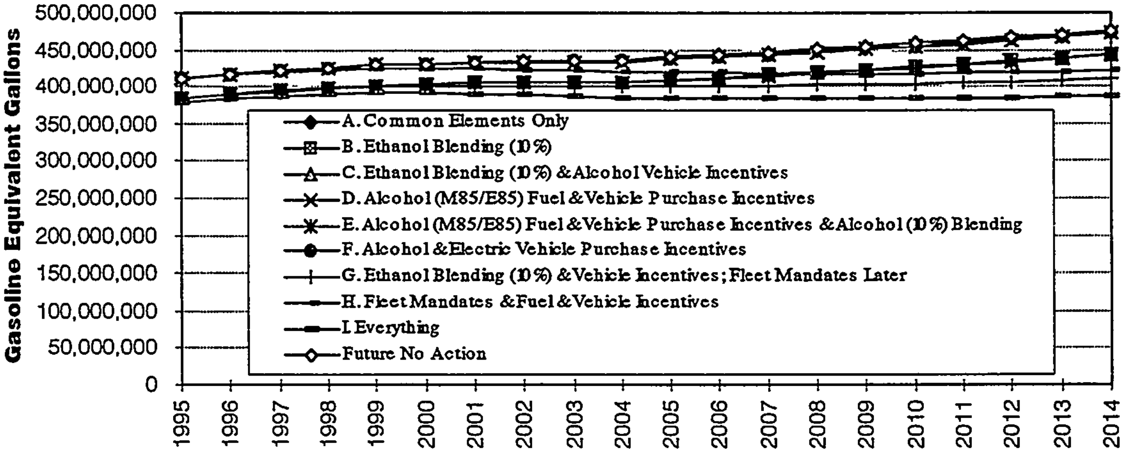
The development of a local alternative fuels program could have beneficial economic effects such as the preservation and creation of jobs in agriculture and in electric vehicle (EV) support and manufacture. A local alternative fuel industry would also retain within the state a larger portion of its substantial energy expenditures. Such a program could also have a secondary effect of enhancing the state's tourist appeal through maintenance of a thriving agricultural economy, thus reinforcing Hawaii's appeal as a clean and healthy destination. In addition, reduced shipping of crude oil into the state reduces the possibility of oil spills.

Transition to widespread use of alternative fuels is a gradual process, primarily due to the time necessary to introduce AFVs into the vehicle population. Near-term actions to foster the production and use of alternative fuels are necessary first steps to achieve long-term goals.

Certain potential measures to encourage the use of alternative fuels have already occurred to some extent, are occurring or are expected to occur voluntarily, or are essentially non-controversial and non-cost items. These include: provisions that new or replacement fueling facilities be alcohol compatible; the availability of off-peak charging for EVs at reduced rates; the adjustment of fuel tax rates on the basis of energy content; certain requirements that fleets purchase AFVs; and public education and outreach programs.

Measures and groups of measures (scenarios) were evaluated on the basis of effectiveness and cost. Scenarios were developed which included such measures as ethanol blending, alcohol or electric vehicle purchase incentives, and mandates that fleets purchase AFVs. The effectiveness of each scenario was estimated in terms of the amount and cost of gasoline and diesel displaced, the number of alternative fuel vehicles in use, and the scenario's employment potential. Projected gasoline and diesel demand under various scenarios is shown in Figure 3.

Figure 3.
Projected Gasoline and Diesel Demand Under Various Scenarios, 1995-2014



RECOMMENDATIONS

Although aviation is the dominant sector with respect to fuel use, this report concludes that the ground transportation sector is the sector most amenable to impact by state and local actions. Chapter 11 presents an action plan to influence energy use in the ground transportation sector. Experience on the mainland and elsewhere has shown the need for successful programs to be integrated, publicly-supported packages of requirements, incentives, research, outreach and public information, governmental actions and monitoring programs. Because of these interrelationships, it is appropriate to integrate all elements relating to ground sector energy use into a package addressing conservation, alternative fuel supply and demand, and alternative fuel vehicle (AFV) supply and demand. The plans must be evaluated for personnel and resource requirements.

Analyses presented in Chapter 10 show that an alcohol gasoline blend program is the most cost-effective means of encouraging the use of significant quantities of renewable, locally produced alternative fuels. As discussed in Chapter 10, projected costs may be justifiable since jobs would be preserved and created immediately as energy crop production commenced.

Reducing the cost of off-peak recharging of electric vehicles, adjusting fuel taxes to be based on energy content, and public education programs are recommended low-cost and low-risk components of a near-term program.

It is also recommended that state transportation energy efforts focus on energy conservation and to a lesser degree, congestion relief. The goal of energy conservation efforts would be to increase the average fuel efficiency of motor vehicles in the state and change travel behavior and land use patterns. Improving and expanding public transportation and other methods of decreasing vehicle miles traveled would have immediate energy savings, while transportation and land use planning would have the greatest projected long-term energy conservation potential.

Research and development programs would also play an important part in the achievement of Hawaii's energy goals. It is recommended that in the near-term the state research such areas as fleet purchase requirements and effectiveness in other states, methods to reduce the number of vehicle miles traveled, and programs to increase fuel efficiency.

The near-term program would last approximately seven years. By that time it is estimated that approximately 10,000 alternative fuel vehicles would be in use in Hawaii.

At the beginning of the mid-term program, it would be appropriate to reevaluate the cost, availability and desirability of the various alternative fuel vehicles and incentives. Fleet incentives and mandates may also be part of the mid-term program.

In the mature program, alternative fuels would have achieved cost-effective scales of production and distribution, and government subsidies and incentives would be phased out.

In developing a comprehensive state energy program, the ground transportation sector is an area where significant energy savings and petroleum substitution can be achieved. A balanced approach incorporating conservation, alternative fuel measures, research and development, out reach and monitoring is recommended. Conservation measures, which would reduce the number of vehicle miles traveled and reduce congestion, could be a central part of state policy. Reduced off-peak recharging rates for EVs, fuel taxes based on energy content and public education programs are essential to the continued and expanded use of alternative fuels and vehicles. Alcohol blending, fleet purchase mandates and vehicle purchase incentives could also be implemented. Research and monitoring of ground sector transportation issues need to continue and the public must be educated and informed of the options and policies affecting transportation in the state.

CHAPTER 1

PROJECT PURPOSE

1.1 RESPONSIBILITY FOR STATEWIDE ENERGY CONSERVATION, PLANNING, AND ALTERNATE ENERGY DEVELOPMENT EFFORTS

This study was prepared for the State of Hawaii Department of Business, Economic Development and Tourism (DBEDT) as part of the Hawaii Energy Strategy program. Authority and responsibility for energy activities such as the Hawaii Energy Strategy belong to the Director of DBEDT as the State Energy Resources Coordinator. Section 196-4 of the Hawaii Revised Statutes (as amended) establishes twelve specific powers and duties of the Energy Resources Coordinator, which include:

- formulating plans, including objectives, criteria to measure accomplishment of objectives, programs through which the objectives are to be attained, and financial requirements for the optimum development of Hawaii's energy resources;
- conducting systematic analysis of existing and proposed energy resource programs, evaluating the analysis conducted by government agencies and other organizations and recommending to the Governor and to the Legislature programs which represent the most effective allocation of resources for the development of energy sources;
- formulating and recommending specific proposals, as necessary, for conserving energy and fuel, including the allocation and distribution thereof, to the governor and to the legislature;
- assisting public and private agencies in implementing energy conservation and related measures;
- developing programs to encourage private and public exploration and research of alternative energy resources which will benefit the state;
- conducting public education programs to inform the public of the energy situation as may exist from time to time and of the government actions taken thereto; and
- serving as consultant to the governor, public agencies and private industry on matters related to the acquisition, utilization and conservation of energy resources.

1.2 STATE ENERGY OBJECTIVES

The state energy objectives are contained in the Hawaii State Planning Law, Hawaii Revised Statutes (as amended), Chapter 226, which states:

> *"226-18 Objectives and policies for facility systems--energy.*
>
> *(a) Planning for the state's facility systems with regard to energy shall be directed towards the achievement of the following objectives:*
>
> *(1) Dependable, efficient, and economical statewide energy systems capable of supporting the needs of the people;*
>
> *(2) Increased energy self-sufficiency where the ratio of indigenous to imported energy use is increased; and*
>
> *(3) Greater energy security in the face of threats to Hawaii's energy supplies and systems.*
>
> *(b) To achieve the energy objectives, it shall be the policy of this State to ensure the provision of adequate, reasonably priced, and dependable energy services to accommodate demand.*
>
> *(c) To further achieve the energy objectives, it shall be the policy of this State to:*
>
> *(1) Support research and development as well as promote the use of renewable energy sources;*
>
> *(2) Ensure that the combination of energy supplies and energy-saving systems are sufficient to support the demands of growth;*
>
> *(3) Base decisions of least-cost supply-side and demand-side energy resource options on a comparison of their total costs and benefits when a least-cost is determined by a reasonably comprehensive, quantitative, and qualitative accounting of their long-term, direct and indirect economic, environmental, social, cultural, and public health costs and benefits;*
>
> *(4) Promote all cost-effective conservation of power and fuel supplies through measures including:*
>
> *(A) Development of cost-effective demand-side management programs;*
>
> *(B) Education; and*
>
> *(C) Adoption of energy-efficient practices and technologies;*

(5) *Ensure to the extent that new supply-side resources are needed, the development or expansion of energy systems utilizes the least-cost energy supply option and maximizes efficient technologies;*

(6) *Support research, development, and demonstration of energy efficiency, load management, and other demand- side management programs, practices, and technologies; and*

(7) *Promote alternate fuels and energy efficiency by encouraging diversification of transportation modes and infrastructure."*

1.3 THE HAWAII ENERGY STRATEGY PROGRAM

This project is one of seven projects which will produce an integrated energy strategy for the State of Hawaii. Program goals are as follows:

- increased diversification of fuels and sources of supply of these fuels;
- increased energy efficiency and conservation;
- development and implementation of regulated and non-regulated energy development strategies with the least possible overall costs to Hawaii's society;
- establishment of a comprehensive energy policy analysis, planning, and evaluation system;
- increased use of indigenous, renewable energy resources; and
- enhanced contingency planning capability to effectively contend with energy supply disruptions.

1.4 DEVELOPMENT OF A TRANSPORTATION ENERGY STRATEGY FOR THE STATE OF HAWAII

The transportation portion of the Hawaii Energy Strategy consists of three parts:

- an evaluation of transportation energy demand and transportation energy management options;
- an evaluation of transportation energy supply options; and
- preparation of recommendations and a comprehensive transportation energy strategy for the State of Hawaii.

1.4.1 TRANSPORTATION ENERGY DEMAND

Transportation planning has received a great deal of attention in the state, in the various counties, and especially in Honolulu. The issues of highway construction, bus fleet expansion, Transportation System Management (TSM) projects, bikeways, fixed-rail mass transit, etc., are highly controversial issues with many players. Energy concerns have not weighed heavily with those involved in decisions about one particular system over another; historically, the energy demands have not generally been considered or quantified.

In the short term, there are significant and numerous opportunities for energy efficiency and use of alternative fuels in currently existing transportation plans. In the long term, evaluation and consideration (in the early stages of transportation planning) of the energy demands associated with each of the various transportation alternatives is necessary for the success of any long-term transportation energy demand management and planning effort.

1.4.2 TRANSPORTATION ENERGY SUPPLY

Considerable activity in the area of alternative fuel production, demonstration, use, and assessment of impacts has taken place and is ongoing internationally, nationally, and locally. Alternative transportation fuels projects funded by and/or involving the U.S. Department of Energy, the U.S. Department of Agriculture, the U.S. General Services Administration, the U.S. Department of Defense, various national laboratories, the State of Hawaii, the University of Hawaii, each of the counties, and numerous other public and private organizations have been ongoing at various levels in Hawaii for many years. Several of the potential alternative transportation fuels hold significant promise for production and use in Hawaii; however, it is necessary to comparatively evaluate and quantify relative costs, benefits, barriers, infrastructure and other requirements in the Hawaii context.

1.4.3 TRANSPORTATION ENERGY STRATEGY

Hawaii Energy Strategy Project 5, Transportation Energy Strategy Development, was prepared to:

- collect and synthesize information on the present and future use of energy in Hawaii's transportation sector;
- examine the potential of energy conservation to affect future energy demand;
- analyze the possibility of satisfying a portion of the state's future transportation energy demand through alternative fuels; and
- recommend a program targeting the state's transportation sector to help achieve state energy goals.

The analyses and conclusions of this report are to be assessed in relation to the other Hawaii Energy Strategy studies in developing a comprehensive state program.

CHAPTER 2

TRANSPORTATION FUEL CONSUMPTION: EXISTING AND FUTURE BASELINE CONDITIONS

2.1 INTRODUCTION

An increasing focus is being placed in the United States on the use of petroleum in transportation, and Figure 2-1 shows the basis for the concern. Nationally, petroleum use in the electric utility, residential and commercial sectors decreased from 1973 to 1991. However, petroleum demand in the largest consumption sector, transportation, increased.

With respect to Hawaii, Figure 2-2 shows that in 1992, the transportation sector consumed 62 percent of the petroleum used in Hawaii, which represents 55 percent of the total energy used in the state. Table 2-1 shows energy use in Hawaii's transportation sectors between 1981 and 1993. Transportation energy demand in the ground, air and marine sectors increased at an annual rate of 4.78 percent between 1981 and 1990, although overall growth has moderated substantially since 1990, and demand has even declined substantially in the air sector since 1990.

Figure 2-3 shows energy use among the transportation sectors in 1992. Figure 2-3 shows that the air sector leads the others in total energy demand meaning that the large aircraft that travel long distances to and from Hawaii dominate energy demands. This occurrence is unique in the nation since the ground sector is the largest consumption sector in all other states.

There are several concerns stemming from the facts above, including:

- Transportation energy demand has been increasing at a relatively rapid rate.
- Essentially all of the state's transportation energy is supplied by petroleum.
- The use of petroleum in the transportation sector has a large effect on the state's overall petroleum dependence.
- Hawaii is at the end of long petroleum supply chain which is vulnerable to disruption and price shocks.
- Hawaii has the highest retail gasoline prices in the nation.[1]
- The money spent on crude oil and refined product purchased from out-of-state leaves the state.
- There is relatively little that the state can do to affect the energy requirements of the long-haul aircraft that dominate transportation energy demand.

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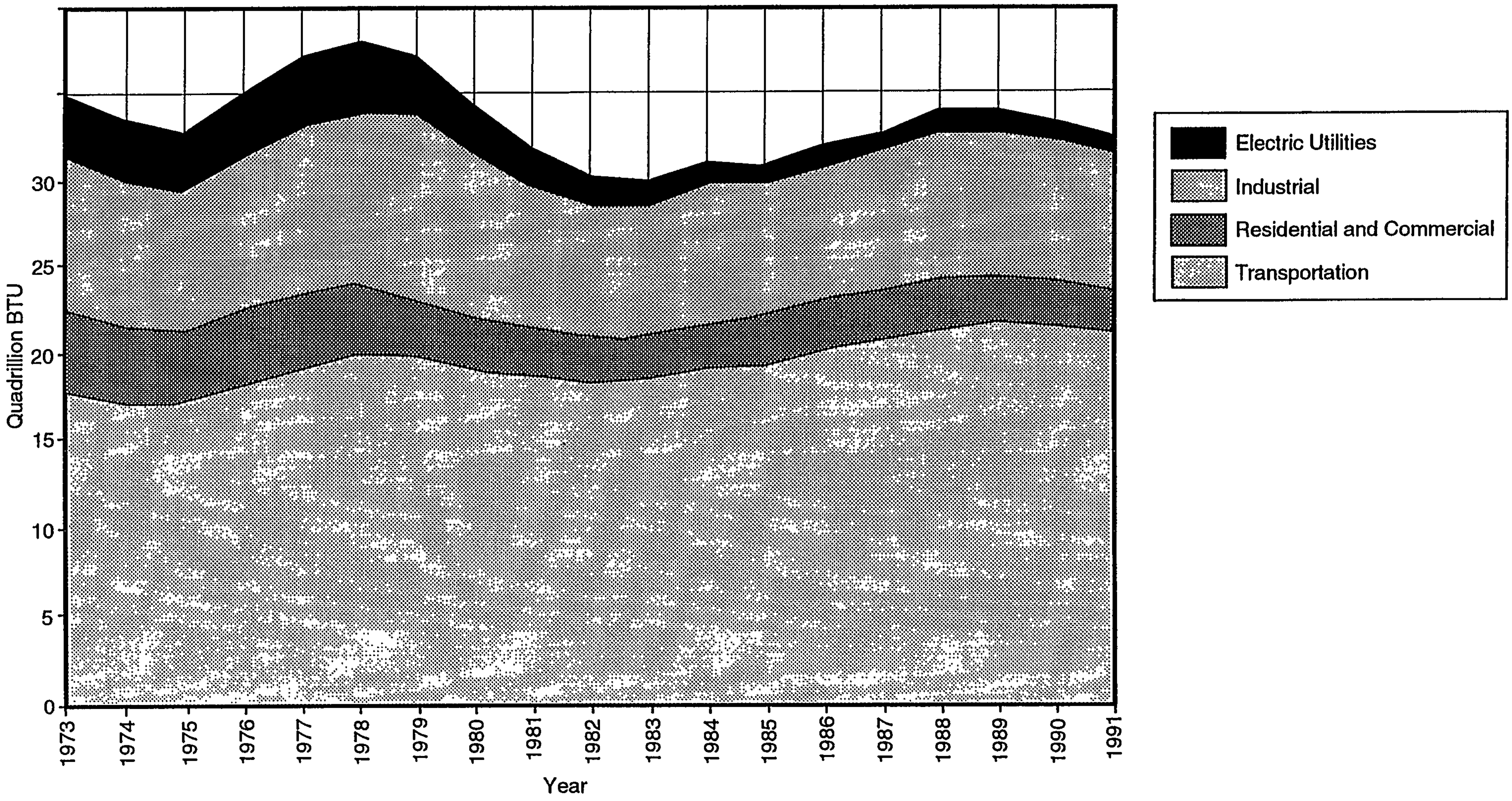
[1] Based on a request from the Legislature, the Attorney General has been studying the possible causes of this situation.

Figure 2-1

U.S. Consumption of Petroleum by End-Use Sector 1973-1991



Source: U.S. DOE /EIA, 1992.

Table 2-1

Statewide Fuel Consumption by Transportation Sector, 1981 to 1993 (Barrels)

Year	Ground[1]			Air[1]	Marine[2]	Total
	Gasoline	**Diesel**	**Total**			
1981	7,230,938	375,490	7,606,428	11,655,973	1,454,931	20,717,332
1982	7,293,915	411,986	7,705,901	11,297,081	1,328,834	20,331,816
1983	7,340,485	931,437	8,271,922	11,943,999	1,173,772	21,389,693
1984	7,676,422	426,011	8,102,433	11,566,914	1,379,865	21,049,212
1985	7,786,224	419,911	8,206,135	12,810,827	940,658	21,957,620
1986	7,956,467	460,811	8,417,278	14,361,110	1,092,277	23,870,665
1987	8,296,995	504,934	8,801,929	16,517,667	1,669,005	26,988,601
1988	8,523,478	501,358	9,024,836	16,703,696	2,804,995	28,533,527
1989	8,789,800	564,987	9,354,787	17,449,603	3,837,727	30,642,117
1990	8,937,677	589,588	9,527,265	17,875,947	4,121,900	31,525,112
1991	8,956,709	595,023	9,551,732	17,366,137	5,830,549	42,300,150
1992	9,074,248	625,917	9,700,165	16,938,141	4,384,245	31,022,551
1993	9,153,428	595,176	9,748,605	14,278,364	4,021,117	37,796,690

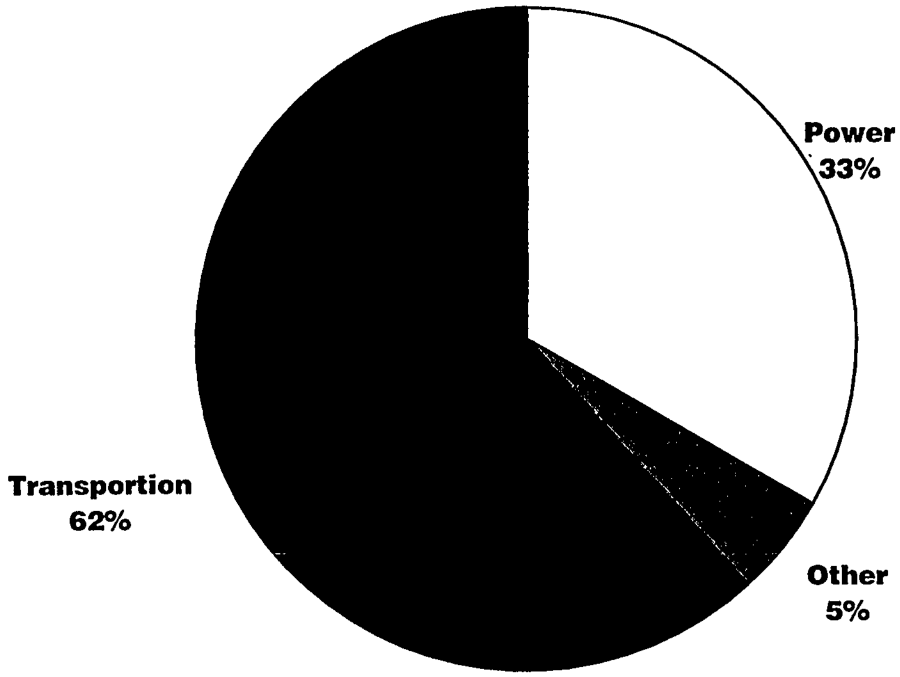
Compounded Annual Growth Rates:

1981 - 1990	2.53%	4.87%	12.27%	4.78%
1990 - 1993	0.77%	-7.22%	N/A	N/A

Sources:
1) Department of Taxation Data
2) State of Hawaii, DBEDT, Energy Division

Figure 2-2

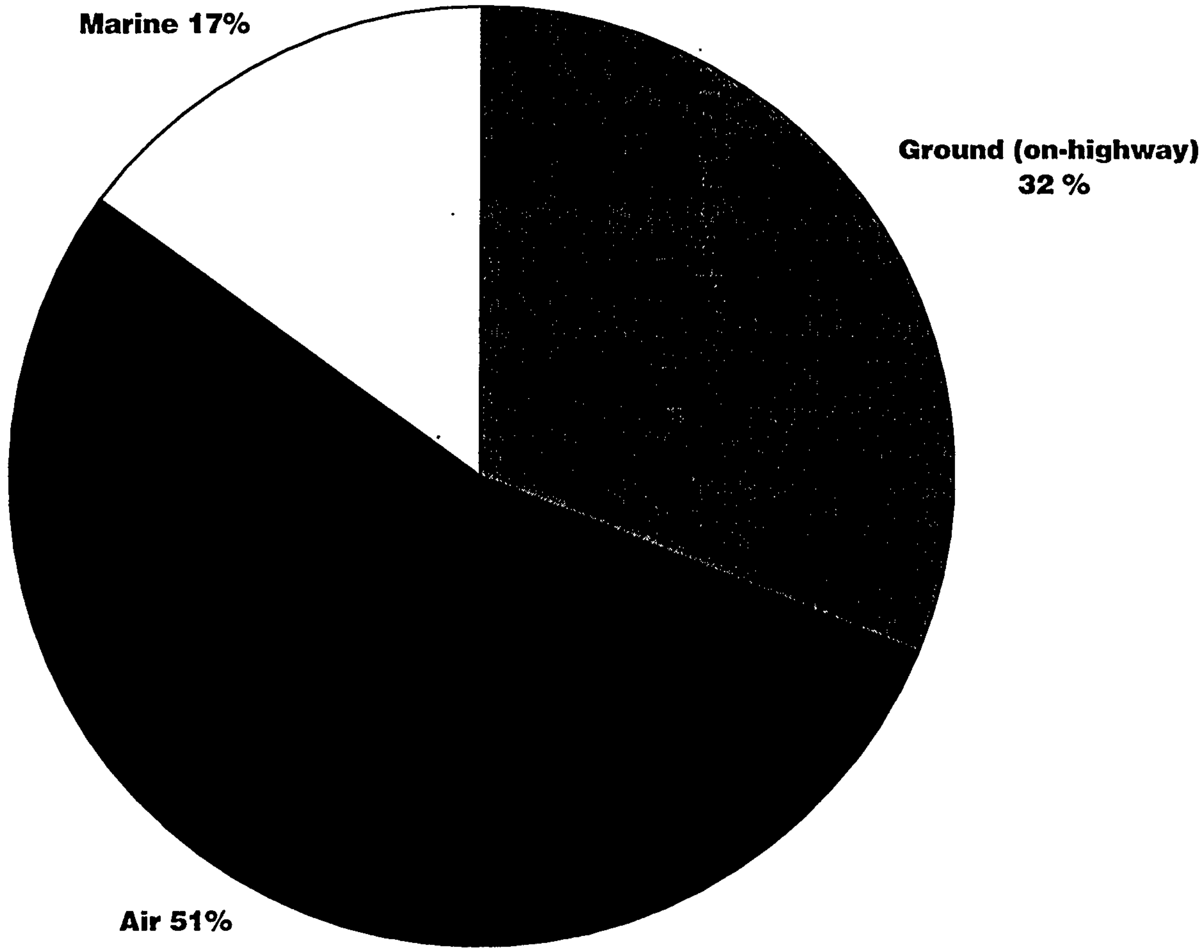
Primary Petroleum Use Sectors, State of Hawaii, 1992



Source: State of Hawaii, DBEDT, Energy Division, 1993.

Figure 2-3

Fuel Consumption by Transportation Sectors, State of Hawaii, 1992



Sources:
1) State of Hawaii, DBEDT, Energy Division.
2) Department of Taxation.

transportation plans (the future "no-action" baseline). Chapter 3 then evaluates the energy savings potentially achievable through conservation, and Chapter 4 evaluates the potential for substituting "alternative fuels"[2] for petroleum.

This chapter projects future energy demand based on adopted transportation plans that have been developed by and for transportation agencies in the state.[3] Major characteristics of the air, ground and marine transportation sectors have also been included in the analysis, such as fleet characteristics, fuel consumption levels, energy efficiency, and projected trends relevant to energy consumption.

The analysis begins with a review of historical data on transportation energy consumption to establish the current relationship between transportation activity and fuel demand. Since transportation plans provide projections of transportation activity, it is then possible to estimate future energy demand using the historical relationship between transportation and energy demand, adjusted by other relevant factors such as improvements in efficiency and effects of congestion. (More information on the approach followed for each sector is included in Appendix A-1.)

The analysis then proceeds to project transportation energy use for the years 1996, 1999, 2004 and 2014.[4] This projection becomes the basis for such analyses as the potential for energy conservation and petroleum displacement.

This study's reliance on existing transportation plans as the primary "driver" of future transportation energy demand is intentional, since it is not the purpose of this project to independently estimate future transportation activity. Development of a Hawaii-specific link between transportation and energy demand enables revisions of the energy demand projections whenever the underlying transportation projections are updated.[5]

The specific numerical values contained in the following projections are intended to provide an order of magnitude estimate. Their use in this report is consistent with this level of precision since they are only used to establish a framework to examine such topics as approximate size of the energy market, relationship of demand to the scale of production of alternative fuels and the timing of introduction of production facilities for alternative fuels. It will be seen later that even order of magnitude projections are useful in screening energy supply options.

Since the ground, air and marine sectors are characterized by different fuels, equipment, infrastructure and demand drivers, each sector is analyzed separately in the following sections.

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[2] A detailed discussion of the definition of "alternative fuels" is deferred to Chapter 4 but the definition includes such transportation fuels as alcohols, propane, natural gas and electricity.

[3] Most of these plans were developed in the late 1980's and early 1990's.

[4] These are the analysis years established for the HES program.

[5] In fact, the key transportation plans underlying the energy demand projections for the ground and air sectors are now being updated, with the revised plans expected to be available in 1995.

2.2 GROUND TRANSPORTATION

2.2.1 HISTORICAL DEMAND

Gasoline and diesel are the two primary fuels used for ground transportation. Gasoline is used in spark-ignition engines (primarily light duty vehicles) while diesel is used in compression-ignition engines (primarily heavy duty vehicles). There is a slight difference in the energy content of the two fuels with gasoline containing 109,000 to 119,000 Btu per gallon and #2 diesel containing 126,000 to 131,000 Btu per gallon (Tshiteya and Vermiglio, 1991).

Figure 2-4 summarizes ground sector energy demand based on Department of Taxation data from 1981 to 1993, distinguishing gasoline and diesel. (Appendix A-1 discusses the selected data sources, and Appendix A-2 provides historical data.) On a volumetric basis, gasoline use greatly exceeds diesel use, representing almost 94 percent of the liquid fuel volume used in the ground sector in 1993. When these volumes are converted to energy content (Btu's), however, diesel has been slowly increasing its market share (from 5.5 percent in 1981 to 7.3 percent in 1992).

Propane is also used as a transportation fuel, both on-highway[6] and off-highway (e.g. forklifts). However, since the amount of propane used for transportation is less than 1 percent of the total amount of propane sold in the state, and propane contributes to less than one percent of the ground transportation fuel demand, propane is not included in the figures.

The total amount of fuel sold for ground transportation in 1993 was over 9.7 million barrels. In 1992, the ground sector represented 32 percent of the volume of transportation fuel sold in the state.

Between 1981 and 1990, ground sector energy demand grew at an average annual rate of 2.53 percent, but as shown in Figure 2-4, growth in demand has slowed since 1990. From 1990 to 1993, average annual growth has been about 0.77 percent.

For reference, annual average growth rates for some related parameters are:

- Statewide "de facto" population[7] from 1981 to 1990: 1.8 percent

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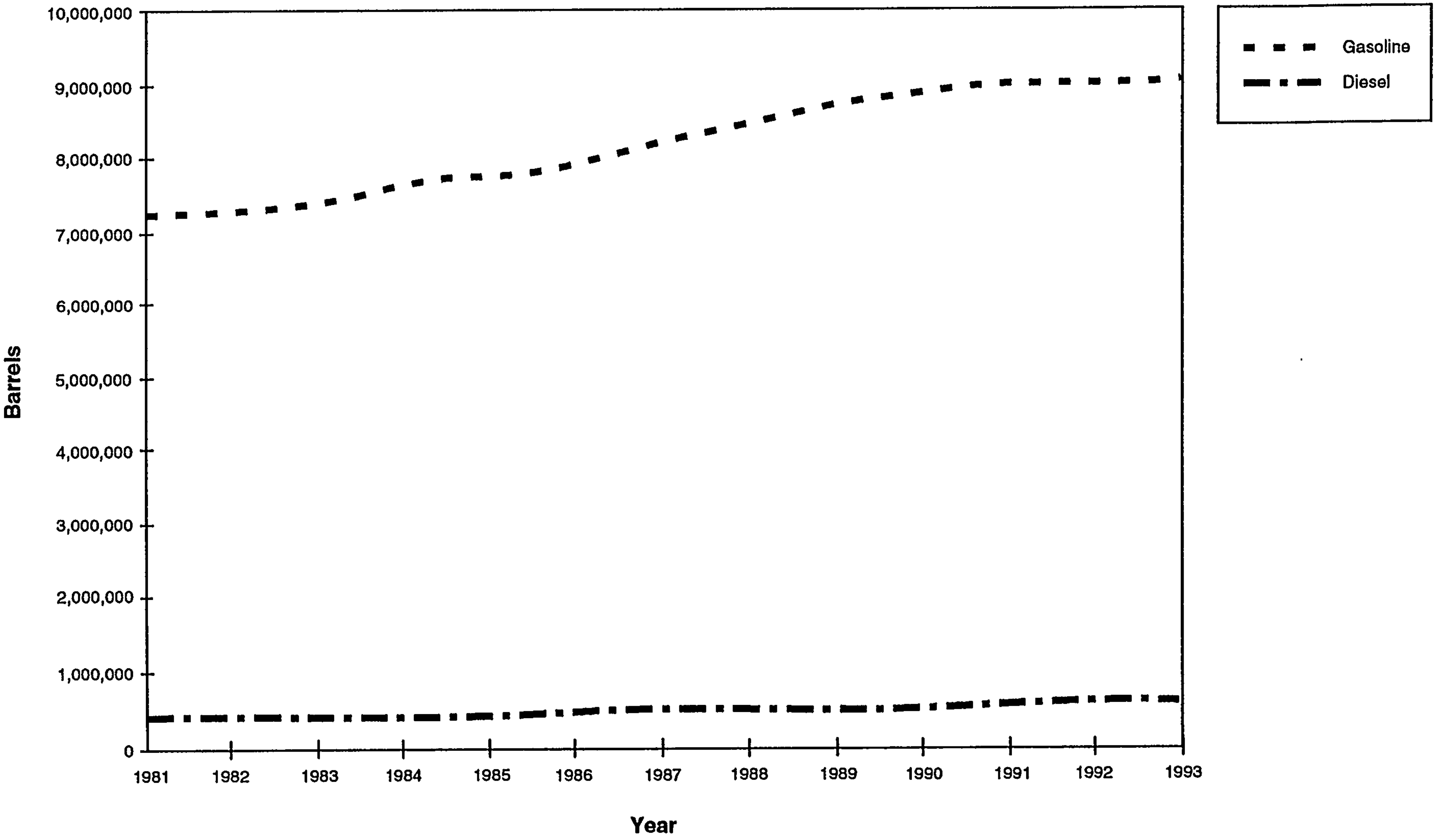
[6] For example, the City and County of Honolulu has over 100 propane-powered vehicles.

[7] "De facto population" includes military personnel and their dependents, and visitors. "De facto population" was considered a reasonable parameter to compare to energy demand growth because this more encompassing definition of population would be expected to be more closely associated with levels of transportation activity than a more limited definition of population.

Figure 2-4

Ground Sector Gasoline and Diesel Demand
Hawaii, 1981 - 1993



- Total number of registered vehicles from 1981 to 1990: 3.7 percent[8]
- Total number of registered vehicles from 1989 to 1992: 0.89 percent

It is assumed that there is an association between vehicle miles traveled (VMT) and fuel consumption. (The projection methodology is based in part on projections of VMT to project future energy demand.) The number of registered vehicles is expected to continue to grow in association with population growth and other factors.[9] It is notable that during the 1980's, energy demand grew much faster than the state's "de facto population."

Figure 2-5 shows ground sector transportation energy consumption by county for 1992. Over two-thirds (67%) of the ground sector energy demand is located on Oahu.

Service stations sell most of the ground transportation fuel (about 80 percent based on Energy Division records), emphasizing the importance of this type of retail outlet in planning for alternative fuels.

2.2.2 FLEET COMPOSITION

Figure 2-6 shows the classification of vehicles registered in the state in 1992. In 1992, passenger automobiles accounted for 79 percent of the vehicles registered in the state.

Additional information on fleet composition is provided in Chapter 4, which introduces the National Energy Policy Act (EPACT) and the Clean Cities Program. EPACT's provisions and the Clean Cities Program target vehicle fleets meeting certain criteria.

2.2.3 FUTURE DEMAND

Demand for ground transportation fuels is projected to increase as shown in Table 2-2. Appendix A-1 presents details of the approach. By 1996, ground sector energy consumption is projected to have increased by 5.5 percent over 1992 levels; by 1999 the increase is projected to be 8.8 percent over the 1992 level; by 2004 the increase is projected to be 13.2 percent over the 1992 level; and by 2014, demand is projected to be almost 21.7 percent more than the 1992 level. These projections are based primarily on increases in travel activity projected in each county's highway master plan (Neighbor Islands) or Regional Transportation Plan (Oahu). The parameter describing transportation activity varied among counties,[10] so the annual percent increase projected for the parameter used by each county was used to drive the projections. In addition to transportation activity, the projections consider projected fuel efficiency improvements as presented in Argonne

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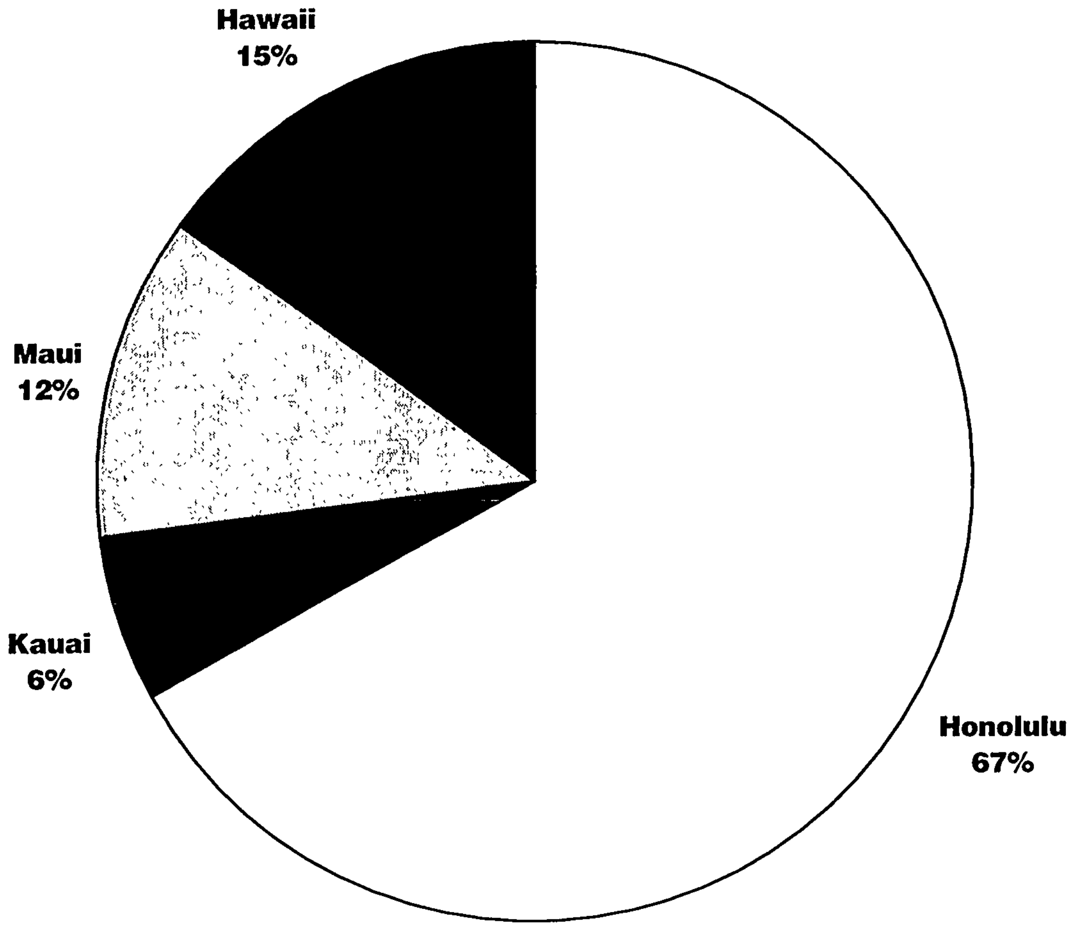
[8] Each county has its own rate of increase in the number of vehicles registered in the county. For purposes of this study, the distribution of vehicles among the counties is important because it indicates where the demand for ground transportation fuels is located. The bulk of the market is located on Oahu, and although the Neighbor Islands have higher rates of growth in their populations, the dominance of Oahu in the state's ground sector energy demand is expected to continue. Based on historical data and an extrapolation of past trends, Oahu had 70 percent of the vehicles in 1990 and is expected to have 61 percent of the vehicles in 2004, when Maui and Hawaii would each have 15 to 16 percent, and Kauai would have about eight percent.

[9] The State of Hawaii, Statewide Transportation Council and Department of Transportation (1991), projected an annual average increase in the number of registered vehicles of 2.12 percent for the period between 1992 and 1997.

[10] The parameter describing transportation activity varied by county, and was daily vehicle trips, daily traffic volumes, or vehicle miles traveled depending on the county.

Figure 2-5

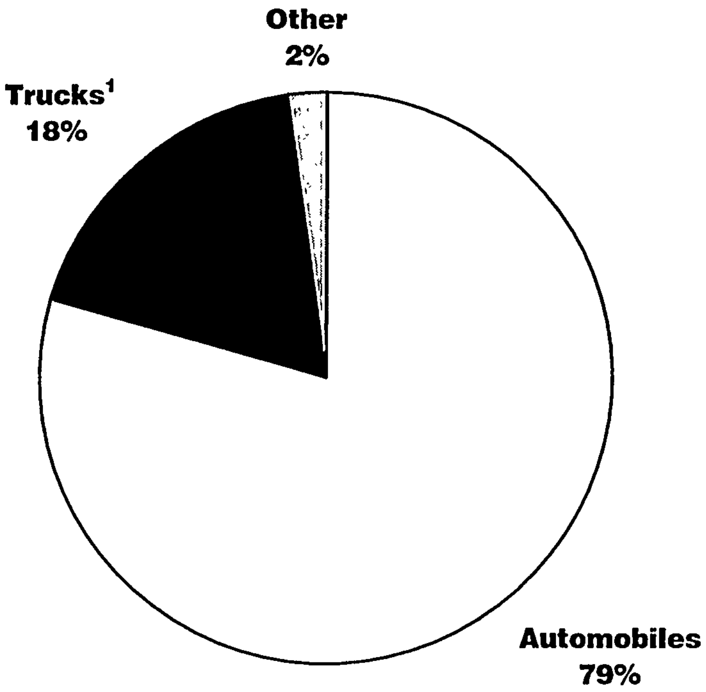
Ground Sector Fuel Consumption by County, 1992



Source: Department of Taxation Data.

Figure 2-6

Distribution of Ground Vehicles
State of Hawaii, 1992



Source: State of Hawaii, DBEDT, 1992.
Note: 1) Vans, pickups, and other trucks under 6,500 lb. in personal use, legally classified as passenger vehicles, are included in the totals for trucks.

Table 2-2

Estimation of Ground Sector Fuel Demand

1992

County	Number of Registered Vehicles in 1992 [1]	Initial Demand (GEB)	Loss Due To Congestion (GEB)	Net Fuel Consumption (GEB) [2]	Fuel Use Per Vehicle in 1992 (without congestion loss)	Percent Improvement in Fuel Efficiency from 1992	Projected Annual Increase in Transportation Activity (percent)
Honolulu	611,513	5,981,260	571,791	6,553,051	9.78	0%	1.13% [3]
Maui	110,003	1,081,995	103,436	1,185,430	9.84	0%	3.93% [4]
Hawaii	113,080	1,346,559	128,727	1,475,286	11.91	0%	3.19% [5]
Kauai	51,165	524,140	50,106	574,246	10.24	0%	3.47% [6]
State Totals	885,761	8,933,953	854,060	9,788,013	10.09	0%	

PROJECTIONS

County	Projected Vehicles	Initial Demand (GEB)	Loss Due To Congestion (GEB)	Gross Demand (GEB)	Percent Improvement in Fuel Efficiency from 1992	Net Fuel Consumption (GEB)	Percent Increase in Fuel Demand Compared to 1992
1996							
Honolulu	639,625	6,256,230	683,428	6,939,657	4%	6,665,498	1.7%
Maui	128,342	1,262,376	137,901	1,400,278	4%	1,344,958	13.5%
Hawaii	128,214	1,526,778	166,785	1,693,562	4%	1,626,656	10.3%
Kauai	58,645	600,766	65,627	666,393	4%	640,066	11.5%
State Totals	954,826	9,646,150	1,053,741	10,699,891		10,277,179	5.0%
1999							
Honolulu	661,555	6,470,721	739,246	7,209,968	7%	6,711,501	2.4%
Maui	144,076	1,417,136	154,807	1,571,944	7%	1,463,266	23.4%
Hawaii	140,880	1,677,601	183,260	1,860,861	7%	1,732,209	17.4%
Kauai	64,964	665,501	72,699	738,200	7%	687,164	19.7%
State Totals	1,011,475	10,230,959	1,150,013	11,380,973		10,594,140	8.2%
2004							
Honolulu	699,787	6,844,674	832,277	7,676,951	14%	6,615,446	1.0%
Maui	174,701	1,718,368	187,714	1,906,082	14%	1,642,525	38.6%
Hawaii	164,830	1,962,803	214,416	2,177,219	14%	1,876,171	27.2%
Kauai	77,045	789,261	86,219	875,480	14%	754,426	31.4%
State Totals	1,116,364	11,315,106	1,320,625	12,635,731		10,888,569	11.2%
2014							
Honolulu	783,007	7,658,660	1,018,338	8,676,999	21%	6,877,325	4.9%
Maui	256,865	2,526,536	275,998	2,802,534	21%	2,221,268	87.4%
Hawaii	225,639	2,686,908	293,517	2,980,425	21%	2,362,263	60.1%
Kauai	108,365	1,110,108	121,268	1,231,376	21%	975,979	70.0%
State Totals	1,373,876	13,982,213	1,709,121	15,691,334		12,436,835	27.1%

GEB = Gasoline equivalent barrels. 1 GEB = 4788000 British thermal units (lower heating value)

Sources:

1) "State Data Book, 1992," Table 507.
2) From Department of Taxation Data for on-highway fuel use.
3) "Oahu Regional Transportation Plan," OMPO, June 1991.
4) "Maui Long-Range Highway Planning Study - Island-Wide Plan - Final Report," SDOT, May 1991.
5) "Island of Hawaii Long-Range Highway Plan - Final Report," Parsons Brinckerhoff, May 1991.
6) "Kauai County Highway Planning Study - Final Report," SDOT, October 1990.

National Laboratory (1991), projected changes in each county's vehicle fleet composition, and projected levels of future congestion.

A 1.05 percent annual increase in Statewide ground sector transportation energy demand is projected between the years 1992 and 2014. This projection could be an overestimate since it is driven by studies that were performed in the late 1980's, towards the end of a period of rapid growth in the state. Economic growth had slowed between 1990 and the date of completion of this report. The underlying transportation studies are presently being revised. The intent of this project is to examine relationships between measures of transportation activity and to develop methods of projecting energy and fuel demands implied by projected levels of transportation activity. It will be possible, therefore, using methodologies developed in this report, to revise and update energy demand projections to be consistent with the updated transportation projections.

The potential effects of conservation and the potential for petroleum displacement are discussed in Chapters 3 and 4.

2.3 AIR TRANSPORTATION

Of the three transportation sectors, air transportation has consistently been the largest fuel consumer from 1981 to 1993 (see Table 2-1).

Table 2-3 tabulates fuel use in the state's aviation sector from 1981 to 1993 based on Department of Taxation data.[11] Approximately 80 percent of the demand derives from outbound overseas flights, with the balance fueling interisland activity. From 1981 to 1990, growth occurred at an annual average rate of almost 4.87 percent. Between 1990 and 1993 demand decreased at an average annual rate of 7.22 percent.

Tables 2-3 and 2-4 show the aviation fuel demand calculations. Details of the projection method are discussed in Appendix A-1. The projection is primarily based on forecasts of interisland and overseas passenger and cargo volumes contained in Wilson Okamoto & Associates, Inc. (1990) adjusted by projected improvement in energy efficiency. The forecasts were prepared in 1990 during a period of rapid growth in passenger and cargo volumes. Actual data in subsequent years do not reflect the growth in the aviation section projected by Wilson Okamoto & Associates, Inc. (1990). Figure 2-7 plots both historic data and the projected level of demand for aviation fuel in the state.

Aviation fuel demand for fuel subject to taxation is projected to be about 17 million barrels by 1999 and about 21.6 million barrels by 2014, an annual growth rate of two percent. Outbound overseas flights are projected to represent over 80 percent of the total aviation fuel demand. Since these projections were developed based on taxed aviation fuel, these projections do not include aviation fuel which is not taxed, such as bonded fuels for international operations sold through duty free operations such as Hawaii Fueling Facilities Corporation (HFFC).

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[11] Department of Taxation data was the approved data set for this analysis.

Table 2-3

Aviation Passenger Volumes, Fueling Records and Projections

	No. of Passengers (1)			Fueling Ratio (2)					
	Interisland	Outbound Overseas (Plus Transit)		Interisland		Overseas			
Year	Passenger	Passenger	Total	(Barrels)	Gallons/ Passenger	(Barrels)	Gallons/ Passenger	Total (Barrels)	Average of total
1981	6,724,113	5,192,195	11,916,308	838,064	5.23	10,817,909	87.51	11,655,973	41.08
1982	7,327,447	5,504,919	12,832,366	1,316,110	7.54	9,980,971	76.15	11,297,081	36.98
1983	7,037,687	5,536,425	12,574,112	1,183,650	7.06	10,760,349	81.63	11,943,999	39.90
1984	7,632,239	6,076,368	13,708,607	1,728,097	9.51	9,838,817	68.01	11,566,914	35.44
1985	7,878,598	6,193,741	14,072,339	3,598,561	19.18	9,212,266	62.47	12,810,827	38.23
1986	8,340,048	7,001,547	15,341,595	3,952,177	19.90	10,408,933	62.44	14,361,110	39.32
1987	8,802,594	7,394,116	16,196,710	4,699,276	22.42	11,818,391	67.13	16,517,667	42.83
1988	8,964,928	7,985,884	16,950,812	3,389,180	15.88	13,314,516	70.02	16,703,696	41.39
1989	9,634,077	8,329,820	17,963,897	3,961,060	17.27	13,488,543	68.01	17,449,603	40.80
1990	9,907,154	8,606,627	18,513,781	4,104,317	17.40	13,771,630	67.21	17,875,947	40.55
1991	9,368,576	8,235,787	17,604,363	3,473,227	15.57	13,892,910	70.85	17,366,137	41.43
1992	9,568,432	8,405,467	17,973,899	3,042,090	13.35	13,896,051	69.44	16,938,141	39.58
1993	9,345,320	8,205,920	17,551,240	2,855,673	12.83	11,422,691	58.46	14,278,364	34.17

Forecast, 1995 to 2010			
1995	9,676,490	8,774,322	18,450,812
2000	10,556,674	10,373,593	20,930,267
2005	11,516,920	12,264,360	23,781,280
2010	12,564,511	14,499,751	27,064,262

<u>Average Fueling Ratio for 1989 to 1993</u>
<u>(Gallons/Passenger)</u>

15.3	66.8	39.3

<u>Sources</u>:

1) "Hawaii Statewide Airport System Plan", DOT/Airports Division, December 1990.
2) Department of Taxation Data.

Table 2-4

Aviation Fuel Efficiency and Fuel Demand Forecast

1. Fueling Ratio[1]

Year	Gallons / Passengers Intrastate	 Outbound Overseas
Average 1989 to 1993	15.3	66.8

2. Aviation Fuel Efficiency: Annual Rate of Change in Fuel Demand Projected by Others, 1985 - 2010[2]

ANL	FAA	EIA	Average
-1.61%	-1.73%	-1.88%	-1.74%

3. Projected Fuel Efficiency

Year	Gallons / Passengers Intrastate	 Outbound Overseas
1996 fuel efficiency rate	14.520	63.370
1999 fuel efficiency rate	13.770	60.120
2004 fuel efficiency rate	12.610	55.070
2014 fuel efficiency rate	10.580	46.200

4. Passenger Forecast[3]

Year	Intrastate	Outbound Overseas	Total
1996	9,846,451	9,073,121	18,919,572
1999	10,374,454	10,031,967	20,406,421
2004	11,318,125	11,860,446	23,178,571
2014	13,470,787	16,578,036	30,048,823

Table 2-4

Aviation Fuel Efficiency and Fuel Demand Forecast (Continued)

5. Fuel Demand Forecast (Barrels)

Year	Intrastate	Outbound Overseas	Total
1996	3,404,059	13,689,611	17,093,670
1999	3,401,339	14,360,044	17,761,383
2004	3,398,132	15,551,304	18,949,436
2014	3,393,355	18,235,840	21,629,195

6. Aviation Fuel Demand Forecasts by Others (Barrels)

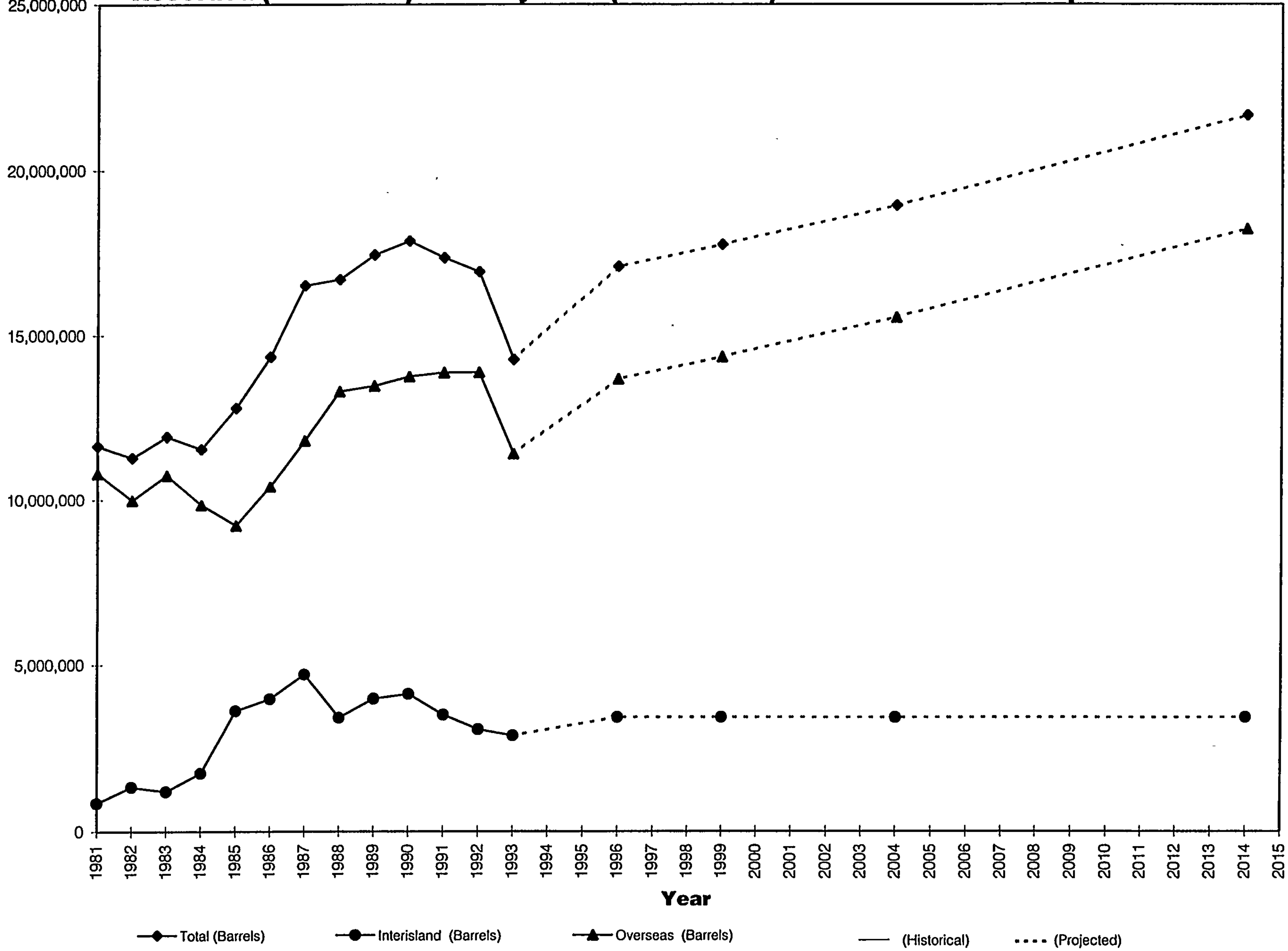
Year	Intrastate	Outbound Overseas	Total
1995	N/A	N/A	21,754,000 [4]
2010	N/A	N/A	31,645,500 [4]
2010	N/A	N/A	33,000,000 [5]

Notes:

1) Based on Department of Taxation Data and Department of Transportation passenger counts.
2) Based on Argonne National Laboratory (ANL) report: FAA = Federal Aviation Administration; EIA = Energy Information Administration, Department of Energy.
3) Projected in "Hawaii Statewide Airport System Plan," adjusted to future analysis years.
4) "Energy Emergency Preparedness," Ed Noda Associates, August 1992.
5) "Phase II Report on a Relocation Program and Development Plan for Petroleum-Oil-Lubricants (POL) Facilities in the Oahu Waterfront," Williams Brothers, November 1992.

Figure 2-7

Recorded (1981-1993) and Projected (1996 - 2014) Aviation Fuel Consumption



Source: Department of Taxation Data; projections by PBQD based on existing transportation plans.

These amounts are substantial.

This study's reliance on existing transportation plans as the primary "driver" of future transportation energy demand is intentional, since it is not the purpose of this project to independently estimate future transportation activity. Linking transportation and energy demand enables revisions of the energy demand projections whenever the underlying transportation projections are updated.

Since a study performed in 1990 was used to drive the projection, demand could be overestimated. Air transportation activity has slowed substantially between 1990 and the date of completion of this study.

2.4 MARINE TRANSPORTATION

Table 2-5 shows historical data on marine transportation fuel consumption based on DBEDT - Energy Division records, and Figure 2-8 plots this data along with the projected future demand. The records show an overall increase of about 183 percent from 1983 to 1990, the biggest percentage increase of the three transportation sectors. This corresponds to an annual growth rate of over 12.27 percent. In 1990, about 93 percent of the demand was for outbound overseas vessels, and the rest was for interisland purposes.

Although there are issues associated with information on petroleum product sales provided to DBEDT under Chapter 486E of the Hawaii Revised Statutes,[12] much of this dramatic growth is believed to have occurred and not be an artifact of the data. Local oil refiners increased sales of marine fuels to foreign fishing fleets and others through active marketing during this period. Because of the range that vessels may travel before refueling, merchant vessels employed in overseas trade can often continue beyond Hawaii without refueling. This option allows marine fuel procurement to be affected by such factors as:

- the energy cost differential between Hawaii and other ports of call, including the effects of changes in exchange rates;
- local marketing efforts in the marine bunkers market; and
- changes in actual levels of shipping activity.

Table 2-6 shows the calculations estimating future marine fuel use. The projections shown here are based on cargo tonnage projections. In subsequent studies, the factors identified above could be added to the analysis. Details of the approach are described in Appendix A-1. Total fuel demand is projected to increase from 4.1 million barrels in 1990 to 6.8 million barrels in 2014, including small recreational boats. However, since the types of factors listed above will continue to affect the local marine bunkers market, projections are

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[12] State of Hawaii, DBEDT (1993) discusses some of the issues associated with this data in more detail.

Table 2-5

Intrastate and Outbound Overseas Cargo Tonnage and Fuel Bunkering Data

	Cargo Tonnage[1]					Marine Fuel Bunkering[2]					
Calendar Year	Intrastate	% of Total	Outbound Overseas	% of Total	Total	Intrastate (Barrels)	Gallons/ Cargo Ton	Outbound Overseas (Barrels)	Gallons/ Cargo Ton	Grand Total (Barrels)	Average Gallons/ Cargo Ton
1983	5,367,994	69.89%	2,312,915	30.11%	7,680,909	510,158	3.99	663,614	12.05	1,173,772	6.42
1984	5,206,745	70.06%	2,224,602	29.94%	7,431,347	520,909	4.20	858,956	16.22	1,379,865	7.80
1985	5,161,665	68.50%	2,373,538	31.50%	7,535,203	418,241	3.40	522,417	9.24	940,658	5.24
1986	5,382,155	68.80%	2,440,370	31.20%	7,822,525	574,316	4.48	517,961	8.91	1,092,277	5.86
1987	6,272,667	71.65%	2,481,469	28.35%	8,754,136	670,425	4.49	998,580	16.90	1,669,005	8.01
1988	7,091,952	72.80%	2,649,390	27.20%	9,741,342	338,871	2.01	2,466,124	39.09	2,804,995	12.09
1989	7,269,413	72.90%	2,701,904	27.10%	9,971,317	275,208	1.59	3,562,519	55.38	3,837,727	16.16
1990	8,195,157	76.48%	2,520,700	23.52%	10,715,857	296,913	1.52	3,824,987	63.73	4,121,900	16.16
						Annual Average:	3.21		27.69		9.72
						1989 - 1990 Average:	1.56		59.55		
	Intrastate and Overseas Cargo Tonnage Forecast[3]					Marine Fuel Demand Forecast[4]					
						Interstate (Barrels)	Gallons/ Cargo Ton	Outbound Overseas (Barrels)	Gallons/ Cargo Ton	Grand Total (Barrels)	
1996	11,138,209	78.52%	3,047,207	21.48%	14,185,415	413,705	1.56	4,295,111	59.20	4,708,816	
1999	12,683,916	79.69%	3,231,658	20.31%	15,915,574	465,077	1.54	4,541,248	59.02	5,006,325	
2000	15,260,095	81.17%	3,539,077	18.83%	18,799,172	555,903	1.53	4,948,809	58.73	5,504,712	
2014	20,412,453	83.09%	4,153,915	16.91%	24,566,368	738,736	1.52	5,750,205	58.14	6,488,941	

Sources:
1) "DOT/HD Cargo Statistics -- Tonnage in Short Tons, Summary by Port and Fiscal Year," 01/30/92.
2) State of Hawaii, Department of Business, Economic Development & Tourism, Energy Division.
3) PB projections based on regression analysis.
4) See Table 2-6.

Table 2-6

Marine Fuel Demand Forecast

1. Fuel Utilization on Rate (average of 1989 and 1990)
(Sources: State of Hawaii, DBEDT, Energy Division; State of Hawaii, DOT, Harbors Division)

Gallons / Cargo Ton	
Intrastate	Outbound Overseas
1.56	59.56

2. Fuel Efficiency Improvement Factor
(Source: Argonne National Laboratory, 1991)[1]

Average annual percentage change from 1985 to 2010: 0.10%

3. Forecast of Fuel Utilization Rate (from step 2)

	Gallons / Cargo Ton	
Year	Intrastate	Outbound Overseas
1996	1.55	59.20
1999	1.54	59.02
2004	1.53	58.73
2014	1.52	58.14

4. Marine Cargo Forecast (PBQD Projections)

	Cargo (Tons)		
Year	Intrastate	Outbound Overseas	Total
1966	11,138,209	3,047,207	14,185,416
1999	12,683,916	3,231,658	15,915,574
2004	15,260,095	3,539,077	18,799,172
2014	20,412,453	4,153,915	24,566,368

5. Fuel Demand Forecast (from steps 3 and 4)

	Fuel (Barrels)			
Year	Intrastate	Outbound Overseas	Recreational Boating	Total
1996	413,705	4,295,111	84,000	4,792,816
1999	465,077	4,541,248	84,000	5,090,325
2004	555,903	4,948,809	84,000	5,588,712
2014	738,736	5,750,205	84,000	6,572,941

Note:

1) "Forecast of Transportation Energy Demand Through the Year 2010," Argonne National Laboratory (1991).

likely to be imprecise, and continued volatility in this consumption sector should be expected as foreign exchange rates and shipping activities change.

2.5 MILITARY TRANSPORTATION

Accurate and comprehensive information on fuels used by the military for transportation and other uses is not readily available. The Department of Taxation data does not address military consumption separately, and although information was requested from the military, complete information for all branches of service and all installations in the state could not be obtained. The only remaining data source is DBEDT - Energy Division records fuel sales, as reported under Chapter 486-E of the Hawaii Revised Statutes (HRS 486-E). These reports include separate categories for sales of fuel to the military. However, a substantial amount of in-state military fuel use could occur without being reported through this mechanism, which only tabulates purchases made on the local market and therefore excludes significant interstate and international shipments.

The data suggest that military fuel purchases on the local market have declined steadily from about 6.6 million barrels in 1981 to 2.6 million barrels in 1990, an overall decrease of 62 percent which corresponds to an average annual decrease of 9 percent. Possible reasons for this decrease are many, and could include:

- actual decreases in military transportation activity;
- reductions in military forces;
- changes in refueling patterns; and/or
- less procurement of fuel through channels that report fuel sales under the HRS 486-E system.

2.6 SUMMARY

2.6.1 HISTORICAL TRENDS

The total amount of petroleum used by all sectors (transportation and non-transportation) in the State of Hawaii increased from about 42.6 million barrels in 1981 to about 48.9 million barrels in 1991. This represents a compounded annual rate of increase over the period of approximately 1.68 percent.

Fuels consumed by the ground, marine and air transportation sectors increased from about 20.7 million barrels in 1981 to about 31.5 million barrels in 1990. The average annual rate of change over this period was approximately 4.78 percent, a substantially greater rate of increase than total energy consumption in the state.

Average annual increases for the three modes between 1981 and 1990 were:

- ground: 2.53 percent
- air: 4.87 percent
- marine: 12.27 percent

However, since 1990, growth in demand has moderated substantially, and demand even decreased by 7.22 percent in the air sector between 1990 and 1993.

Demand by the military for transportation fuels from vendors that report under the HRS 486-E system decreased at an annual average rate of 9.1 percent between 1981 and 1990.

2.6.2 THE "FUTURE NO-ACTION BASELINE"

Total ground, air and marine transportation fuel demand is projected to increase to 40 million barrels by 2014, which corresponds to an annual rate of increase of 1.75 percent (see Table 2-7 and Figure 2-8). The aviation sector is projected to continue as the dominant sector.

Projected annual increases in energy demand for the three modes between 1992 and 2014 are:

- ground: 1.05 percent
- air: 2 percent
- marine: 2.37 percent

It is possible that the transportation studies underlying these projections overestimate future travel, which would cause an overestimation of energy demand. In the ground and air sectors (but not the marine sector), the relevant studies are being updated and should be available in 1995.

Table 2-7

Energy Demand Projections
(Barrels)

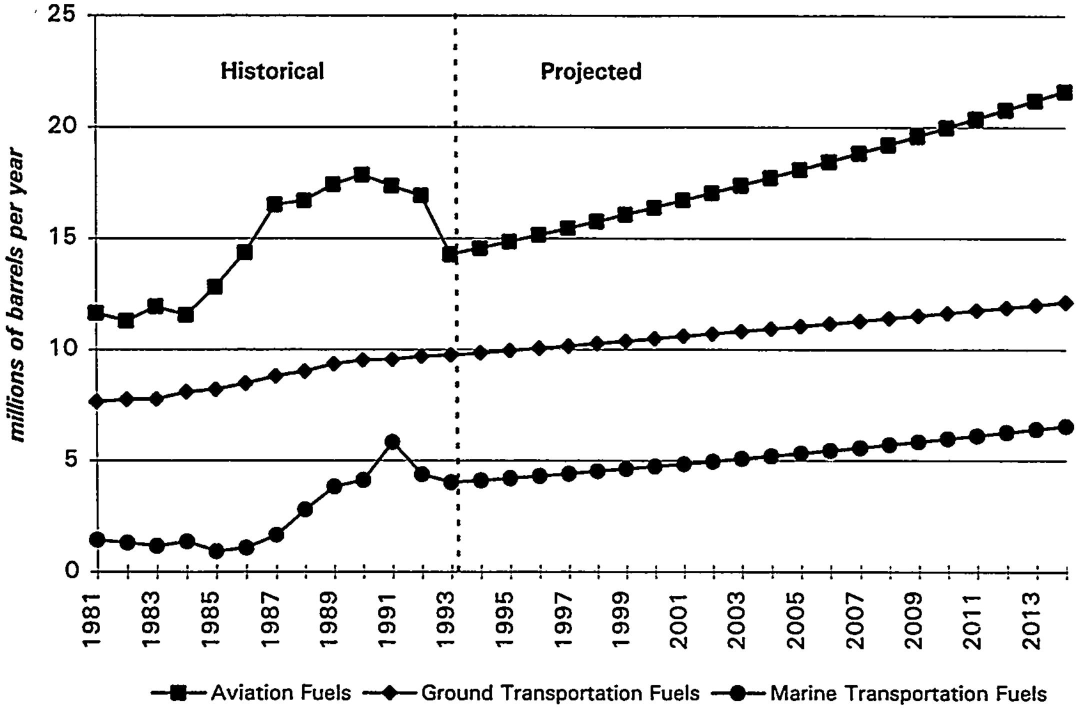
Year	Ground	Air	Marine	Total
1993	9,748,605	14,278,364	4,021,117	28,048,086
1996	10,058,922	17,093,670	4,792,816	31,945,408
1999	10,379,116	17,761,383	5,090,325	33,230,824
2004	10,935,584	18,949,436	5,588,712	35,473,732
2014	12,139,621	21,629,195	6,572,941	40,341,757

Compounded Annual Growth Rates:

1993-2014	1.05%	2.00%	2.37%	1.75%

Sources: Parsons Brinckerhoff, 1994

Figure 2-8
Projected Energy Demand
(Barrels)



CHAPTER 3

ENERGY SAVING POTENTIAL IN HAWAII'S TRANSPORTATION SECTOR

3.1 INTRODUCTION

Chapter 2 projected future fuel demand in the ground, air and marine sectors based on existing transportation plans. These projections illustrate possible energy demand if present trends continue. This chapter explores possible energy conservation and efficiency improvements which could reduce energy demand in the state's transportation sector to below the levels projected in Chapter 2.

The analysis begins with an overview of energy conservation measures applicable to Hawaii's air and marine sectors. However, because Hawaii units of government have few means to actually encourage or impose conservation practices in these sectors, the focus of this chapter then shifts to the ground sector, where the opportunities for state and local implementation of efficiency improvements are greater.

Within the ground sector, this chapter begins with an examination of improvements in vehicular fleet energy efficiency. While a discussion of the means by which increased average fleet efficiency could be achieved is deferred to Chapter 11, it will be shown that, if implemented, increased fuel efficiency would have a significant effect on ground sector energy demand.

The discussion then moves to transportation control measures (TCMs). TCMs initially focused on low-cost improvements to better accommodate transportation demand. Initially, most of the specific measures were transportation system management (TSM) measures that emphasize improving the operating efficiency and maximizing the capacity of the existing transportation system. They usually address localized concerns. Examples of these TSM measures are one-way streets, reversible (contra-flow) lanes, additional bus service, signal timing and synchronization, and similar actions. TSM measures focus on the "supply side" of transportation service.

As system efficiency improves, one might expect that, all other factors remaining constant, transportation energy usage would decrease because of a decrease in traffic congestion. However, the actual situation is not quite this simple for two principal reasons.

First, as transportation system efficiency improves, other factors change. For example, it has been shown repeatedly that there is a latent demand for transportation service. As system efficiency improves and level-of-service (LOS) for travelers improves, additional trips are typically generated. Previously, before the system improvements, these trips would have been foregone.

Second, energy efficiency of internal combustion engine vehicles varies in a complex fashion with vehicle speed. Vehicle efficiency decreases dramatically at speeds below 15 miles per hour. Results of one study indicate that fuel consumption (in miles per gallon, mpg) increases by 30 percent when average speeds drop from 30 to 20 miles per hour. A decrease from 30 to 10 miles per hour results in a 100 percent increase in fuel consumption (California Energy

Commission, 1992b). At lower speeds, various frictional losses predominate.[1] At higher speeds, friction from aerodynamic drag predominates. Somewhere in the middle, at a speed specific to each vehicle but often around 25-35 mpg for a passenger car, maximum fuel efficiency is attained. Therefore, if average speeds increase through transportation system efficiency improvements, depending on the initial speed and the amount of its subsequent change, average fuel efficiency could increase or decrease.

A method developed by the Texas Transportation Institute and used in a report on congestion for the Federal Highway Administration (FHWA) was used to estimate the impact of congestion on energy usage (Schrank, et. al. 1993). The report estimates fuel wasted due to congestion for the years 1986 through 1990 for the City and County of Honolulu. Based on these estimates and state data on fuel consumption in the ground sector for these years, energy wasted from congestion increased from approximately eight percent to ten percent of the total ground sector transportation energy demand on Oahu in those years. The method of Schrank, et. al. (1993) was used to develop estimates of future energy waste from congestion, as reported in Chapter 2.

During the 1980s, the analysis of TCMs expanded to programs that could reduce travel demand, as measured by vehicle trips in congested areas during peak travel periods. Importantly, reducing vehicle trips during the peak periods and in areas of congestion does not necessarily imply reducing person trips. Examples of these transportation demand management (TDM) measures includes enhancing and promoting, and in some cases mandating:

- shifts in transportation mode from single-occupant vehicles (SOVs) to high-occupancy vehicles (HOVs) which are characterized by higher utilization efficiencies (occupants per vehicle), such as commuter vans, buses, car-pools, rail transit vehicles or jitneys;
- shifts to travel during less congested periods ("spread the peak period of travel");
- shifts in choice of travel mode away from motorized vehicles to such modes as bicycling or walking; and
- elimination of the need for travel.

As used in this report, the term TCM encompasses both TSM measures and TDM measures. These two categories are not rigid, however. Also, synergies among TCMs are frequent, and several TCMs are often proposed as a package. Common goals of most of them are to encourage modal shifts from SOVs to some form of HOV, shift the time of travel, and/or reduce the need for travel.

This chapter reviews a large number of TCMs that have been discussed for possible implementation in Hawaii. Over the long term, however, fundamental land use patterns are perhaps the most important factor controlling transportation requirements and the form of the transportation network. With much of the state still not developed in an urban fashion, and with redevelopment opportunities (such as Kakaako), the implementation of wise land use planning practices could provide a future land use pattern in some areas which could then be served

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[1] It should be noted that, with standard automobile engines, if the engines are running but the vehicles are not traveling (for example, when stopped in stop-and-go traffic conditions) the vehicles are burning fuel with an efficiency of zero miles per gallon. Electric vehicles consume little or no energy when stopped. Thus, electric vehicles offer superior energy efficiency in a congested environment.

by an energy-efficient transportation network that, among other characteristics, facilitates bicycling and walking. This chapter discusses some of the current land use planning concepts which could have the effect of reducing transportation energy demand.

Finally, some concluding remarks are offered about the potential of energy conservation in Hawaii's ground transportation sector.

3.2 ENERGY EFFICIENCY IN THE AVIATION AND MARINE SECTORS

3.2.1 COMMERCIAL AVIATION

Spurred on by the petroleum price shocks of the past decades, air transportation has doubled its energy efficiency since the early 1970s. Higher load factors, increased aircraft size, changes in the usage of existing aircraft, selective retrofitting of existing aircraft, and the introduction of more energy-efficient turbofan aircraft have all been implemented. Passenger load factors (the percent of available seats occupied by paying passengers) increased from 50 percent in 1970 to 60 percent in 1980, and stood at 64 percent in 1989 (Davis and Morris, 1992). Average available seats per aircraft increased from 111 in 1970 to 163 in 1985, but declined to 158 in 1989 (this slight, recent decline could be a result of providing more frequent service to hub airports). The provision of more fuel-efficient turbofan planes (rather than the conventional turbo jet) also brought about dramatic improvements in energy efficiency.

Energy efficiency of air transportation in the U.S. has waned in the last few years despite increases in load factors between 1984 and 1989. One factor could be the increase in air traffic congestion, compounded by greater "hubbing" by airlines, which has resulted in greater delays and ground time. Another factor could be that fuel prices have generally stabilized since the late 1980s. In 1970, kerosene jet fuel cost \$0.30 (1989 \$) per gallon. This doubled to \$0.61 per gallon in 1975 and peaked at \$1.37 per gallon in 1981. Prices dropped in the late 1980s to around \$0.60 per gallon. Cheaper fuel reduces the pressure for airlines to convert to more fuel efficient, but expensive, turbofan engines.

The current U.S. commercial fleet has an average efficiency of about 48 seat-miles per gallon (SMPG). Future gains in commercial aviation energy efficiency could be obtained through technological improvements to engines and airframes,[2] technological and procedural

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[2] Since the 1960s, the jet engine has evolved from the turbojet technology to turbofans and then high-bypass turbofans. This progression has produced a 40 percent increase in efficiency. Current high-bypass engines achieve their efficiency by sending 5-6 times as much air around the core as the original straight turbojet engines. This by-pass flow is then accelerated by fans which are driven by the turbine engine. This technology results in greater thrust per pound of fuel consumed than turbojets.

A major propulsion efficiency advance could be realized with ultra-high-bypass engines that boost the bypass ratio from current levels of 6 to 7 up to 15 to 20. Another promising technology is the advanced unducted, or propfan, engine. This technology uses twin counter-rotating propellers, which can achieve a 30 percent increase in fuel-economy over the best current turbofan engines. Their high cost (they cost about twice as much) and concerns about noise, vibration, and maintenance are delaying their acceptance.

improvements to the air traffic control system, and improvements in the use and deployment of planes[3] (Greene, 1992). Average fleet efficiencies of 58 SMPG by the year 2000 and 65 SMPG by 2010 (Greene, 1992) have been discussed, which would represent 20.8 percent and 35.4 percent increases, respectively, over the current average SMPG.

3.2.2 MARINE SECTOR

Energy saving strategies in the marine sector include fuel-efficient operating procedures, manufacturer engine exchange programs, and engine downsizing (Argonne National Laboratory, 1991).

Improvements in operating procedures could save energy. Crew training would be required and financial incentives for fuel-efficient operations could be offered (Argonne National Laboratory, 1991).

Marine engines, especially those found in tugs, are typically two-stroke diesels with long operating lives. Four-stroke diesels, with higher stroke-to-bore ratios, are available and their use would reduce fuel consumption by 5 to 10 percent or more. The longevity of marine engines slows their replacement rate, however. Manufacturers' exchange programs could be implemented.

Replacing existing engines with less powerful ones could also achieve energy savings since diesels operate most efficiently at full power, and marine engines typically operate well below full power. However, use of this technique would depend on specific details of each vessel.

Another technological advance expected to bring increased fuel efficiency is in the field of advanced, high-temperature materials that will permit an increase in ignition and combustion temperatures, and reduce engine weight (Greene, 1992). Advanced light-weight ceramic and metal composite materials could allow an increase in turbine inlet temperatures to over 2500°F while reducing engine weight. At present, the brittleness and sensitivity to flaws of these materials inhibit their use (Greene, 1992).

Energy-efficiency improvements may also be achieved by reductions in aerodynamic drag and airframe weight. At low speeds, air flows over an airfoil (wing) in smooth streamlines (laminar flow). As speed increases, a greater fraction of the air flow becomes turbulent, greatly increasing drag. Advanced supercomputer simulations are being used to help design wings that maintain laminar flow at high speeds. Design concepts include the "smart wing," which would automatically change shape during flight. Another concept would be a wing with grooves or microscopic holes towards the front (through which air would be drawn to reduce turbulence) and ultra-smooth wing surfaces behind to maximize natural laminar flow.

It is not presently feasible to achieve laminar flow over fuselages because of the turbulence they create. Large-eddy breakup (LEBU) devices (inserting small grooves aligned with the direction of airflow and thin plates suspended in the turbulent layer around the fuselage) have been shown in wind tunnel tests to reduce frictional drag by as much as 10 percent (Greene, 1992).

New composite lightweight materials could reduce airframe weight by 30 percent while achieving equal or better structural strength (Greene, 1992). The next century may see planes of 80 percent composite materials in contrast to today's commercial planes, which are 97 percent metal. Lighter airframes require smaller engines, lighter engines allow reductions in an airframe's mass, and both reduce energy requirements.

[3] Airport congestion will necessitate the use of increasingly large planes. Boeing expects that more than half the seats that it will produce after 1995 will be in aircraft of 350 seats or more, and two thirds of the aircraft that it expects to sell would have more than 170 seats (Greene, 1992). Larger planes are generally more efficient in terms of SMPG. Therefore, the trend towards larger planes should increase overall fuel economy.

Greater airport congestion will also require improved tools for controlling airport operations (Greene, 1992). Increasing the number and size of airports has been the historic means of combating air traffic congestion. However, given the scarcity of land in many metropolitan areas, and the environmental impacts associated with airport development, the viability of this option is decreasing in most places. Capacity-building measures must be implemented, such as reducing radar scan frequency to 0.5 seconds (short scan), reducing aircraft stagger or lateral separation to 1.5 miles, reducing aircraft spacing from 4,300 to 2,500 feet on parallel runways, and shortening converging runway requirements (Argonne National Laboratory, 1990). However, given the expected increases in air traffic, improvements to airport operations may only maintain present levels of service.

New engine technologies, such as turbo-compounding and rankine bottoming cycles, have demonstrated fuel savings of 5 to 7 percent and 12 percent, respectively (Argonne National Laboratory, 1991).

3.2.3 LOCAL CONTROL OVER ENERGY USE IN AIR AND MARINE TRANSPORTATION

While it appears that there are significant energy-saving opportunities in both the air and marine sectors, the opportunity for government in Hawaii to accelerate the implementation of these measures is limited. The ability of any state to regulate aircraft and merchant vessels involved in international or interstate commerce is small. Hawaii is also a small market, and not in a position to affect the offerings of engine, plane and ship manufacturers, or influence owner purchase requirements.

Because of the limited scope for Hawaii's government to affect energy conservation in the air and marine sectors, the rest of the discussion focuses on Hawaii's ground sector.

3.3 ENHANCED GROUND TRANSPORTATION VEHICLE FUEL EFFICIENCY STANDARDS

One means of decreasing energy demand in the ground sector would be to increase the average fuel efficiency of the vehicles. The production of more fuel-efficient vehicles is not technically difficult. In 1994, the Environmental Protection Agency (EPA) rated five subcompacts as having fuel efficiencies greater than 47 mpg. Car manufactures argue that the more fuel efficient vehicles are hard to sell given current, relatively low gasoline prices. Technology exists, however, to substantially increase fuel economy. Before discussing implementation mechanisms and issues, it is informative to estimate how much energy could be saved through fleet efficiency improvements. The discussion of implementation mechanisms and issues is deferred to Chapter 11.

It is important to note that the efficiency improvements assumed in the Chapter 2 estimates become quite dominant by 2014, when efficiency is projected to be 38 percent higher than in 1992. Such improvement would start to cause energy demand to decrease even as transportation activity increases. However, achieving such improvement is speculative. The fundamental point is that efficiency has a powerful effect on energy demand, and the efficiency improvements assumed in Chapter 2 would, of themselves, save much energy.

The federal Corporate Average Fuel Economy (CAFE) standards law[4] preempts (prohibits) states from setting their own fuel efficiency standards. However, it is not inconceivable that this could change. What would be the effect if Hawaii were to improve upon the efficiency improvements in Chapter 2? Large effects would indicate that it could be desirable to amend the federal law or approach fuel efficiency indirectly. The approach taken here was to use a

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[4] Title V of the Motor Vehicle Information and Cost Savings Act, 15 U.S.C. 2001-2013.

fuel efficiency factor that was either 5 or 10 percent above the baseline energy efficiency improvements that were assumed in the initial projections (see Appendix A-1 for a more complete discussion of the calculation method). The future baseline calculations were based on projected average fleet efficiencies as reported in The Forecast of Transportation Energy Demand Through the Year 2010 (Argonne National Laboratory, 1991).

Projected energy savings through increased fleet efficiency are shown in Table 3-1. If Hawaii were to implement fuel efficiency standards higher than the nation, energy would be saved. The estimates in Table 3-1 are somewhat high because fleet turnover has not been considered. The savings are large enough to suggest that the state could consider means of influencing the fuel efficiency of vehicles in the state.

In summary, modifying fuel efficiency is a powerful means of controlling energy demand.

3.4 GROUND TRANSPORTATION CONTROL MEASURES (TCMS)

3.4.1 BACKGROUND

TCMs (defined above in Section 3.1) are currently much discussed because of public frustration with growing traffic congestion problems. On Oahu, given the loss of funding for Honolulu's rail transit program in 1993, and the prominent position that the rail system had in Oahu transportation plans, government leaders and citizens' groups are re-examining a wide array of TCMs to deal with congestion problems.

TCMs that have been discussed for application on Oahu are summarized in Table 3-2, and include the following:

- Operational modifications to improve traffic flow;
- Intersection and roadway modifications;
- Freeway operation modifications;
- Roadway enforcement and management;
- Vehicle use limitations;
- High occupancy vehicle (HOV) facilities;
- Intelligent Transit, (“smart street/vehicle concepts”);
- Bicycle and pedestrian facilities;
- Public transit expansion;
- Operational improvements in transit service;
- Park-and-ride facilities;

Table 3-1

Energy Savings with Hawaii Vehicle Efficiencies Higher than National Average

Year	National Baseline (MPG)	5% Improvement Over National Baseline[1] (Barrels of Gasoline)	10% Improvement Over National Baseline[1] (Barrels of Gasoline)
1996	19.00	511,726	1,023,451
1999	19.60	527,758	1,055,515
2004	21.00	549,090	1,098,179
2014	22.40	590,190	1,180,379

Note:

1) National baseline is the vehicle efficiency projected for the nation in the Forecast of Transportation Energy Demand through the Year 2001 (Argonne National Laboratory, 1991).

Table 3-2

Summary of Transportation Control Measure Effectiveness

Measure	Effective Period	Measure of Effectiveness	Level of Effectiveness[1]	Observed Locations
1. Operational Modification to Improve Traffic Flow				various on Oahu
Conversion of a street pair to one-way operations	peak hours	vehicular capacity	10-20% increase	
Reversing one lane on a six-lane roadway		vehicular capacity	33% increase	
Conversion of on-street parking to one lane		vehicular capacity	proportional to number of lanes	
Traffic signal coordination		travel time	at least 10-20% reduction	
Traffic signal coordination		vehicular capacity	small increase	
2. Intersection and Roadway Modifications				
Prohibition or separation of left-turn vehicles	peak hours	vehicle queuing & delays	20-30% reduction	various
3. Freeway Operations				
Ramp metering	peak hours	travel volumes	10-20% increase	Detroit, Los Angeles, Minneapolis & numerous other metropolitan areas
Ramp metering		travel speeds	30-40% increase	
Ramp metering		travel time	10-40% reduction	
Ramp closures		travel time	increase for some drivers	
4. Roadway Enforcement and Management				
Incident management systems		congestion	30% decrease	major urban highway
Non-stopping zones, parking restrictions	peak hours	travel speed	increase	Boston
Non-stopping zones, parking restrictions	peak hours	travel time	>30% reduction	Boston
Non-stopping zones, parking restrictions	peak hours	vehicular capacity	30-40% increase	Boston
Incident patrol	peak hours	congestion	<60% decrease	Chicago
5. Vehicle Use Limitation				
Auto licensing scheme In Central Business District		inbound vehicle trips	50% reduction	Singapore
Auto restrictions iin Central Business District		traffic volumes	5% reduction	Boston
6. High Occupancy Vehicle (HOV) Facilities				
HOV lanes with other TSM measures		auto trips	10-15% reduction	California

Table 3-2

Summary of Transportation Control Measure Effectiveness (continued)

Measure	Effective Period	Measure of Effectiveness	Level of Effectiveness[1]	Observed Locations
7. Intelligent Transit ("Smart Street/Vehicle Concepts")				
Automated message signs		traffic volume	5-10% diversion in advance	New York State
Controlled segments		traffic accidents	5% decrease	New York State
8. Bicycle and Pedestrian Facilities				
Bicycle use		participation	3-11% increase	national study
Walking		participation	3-16% increase	national study
Effect on auto travel		mode switch	1% from auto to non-auto	California
9. Public Transit Expansion				
Expansion of trunk and collector bus route service		ridership	0.3-0.8% increase per 1% increase in bus service	
Reduced headways/increased frequency of service		ridership capacity	0.5% increase per 1% increase in frequency	
10. Operational Improvements in Transit Service				
Removing selected stop signs		travel time	5-15% reduction	San Francisco
Parking and traffic enforcement		time passing intersection	30% reduction	San Francisco
Bus pre-emption		number & duration of delays	75% - 90% and 6 to 11 seconds reduction	San Francisco
11. Park-And-Ride Facilities				
Parking-and-ride facilities		vehicle mile traveled	1-4% reductions	Texas and Connecticut

Table 3-2

Summary of Transportation Control Measure Effectiveness
(continued)

Measure	Effective Period	Measure of Effectiveness	Level of Effectiveness[1]	Observed Locations
12. Public-Transit Marketing				
Fare structure/pricing		transit ridership	0.3% increase per 1% and decrease in fare	
Voucher programs		transit ridership	up to 17% increases	
Regional transit guides		transit ridership	15-20% increases	New York City
13. Paratransit - Premium Subscription Express Bus Service				
Premium subscription express bus service		travel times	competitive with the auto	
14. Paratransit - Jitneys				
Jitneys services	daily	traffic volume	0.15% decrease	Oahu (studied)
Jitneys services	peak hour	traffic volume	0.5% decrease	
15. Paratransit - Shared Ride Taxi				
Shared ride taxi services		rider trips	50-100% increase than single ride taxi	
16. Guaranteed Ride Home				
Guaranteed Ride Home		solo driving trips	71% reduction (in trips made by the 8.5% solo drivers in study)	Bellevue, Washington
Guaranteed Ride Home		bus trips	12% increase	Bellevue, Washington
Guaranteed Ride Home		carpool trips	2% reduction	Bellevue, Washington
Guaranteed Ride Home		vanpool trips	64% increase (mostly carpool participants switching to van pools)	Bellevue, Washington

Table 3-2

Summary of Transportation Control Measure Effectiveness (continued)

Measure	Effective Period	Measure of Effectiveness	Level of Effectiveness[1]	Observed Locations
17. Areawide Rideshare Program				
Vanpool programs		total VMT	0.05-0.28% reduction	
Vanpool programs		work trip VMT	0.14-0.10% reduction	
18. Controls Affecting Parking Supply				
Parking constraints		traffic volume in the area	>5% reductions	Downtown Honolulu
Charge options		commuting trips	11% reductions	financial district
Charge options		commuting trips	16-20% reductions	C&C, State of HI
Cash out		commuting trips	7% reductions	financial district
Cash out		private sector trips	7.5-12.4% reductions	various-Oahu
Charge with travel allowance		commuting trips	9% reductions	financial district
Charge with travel allowance		commuting trips	13-16% reductions	C&C, State of HI
Parking options		commuting trips	10-15% reductions	Kakaako
19. Pricing Actions Affecting Parking				
Doubled long-term parking rates		parking volume	long-term parking decreased	
Doubled long-term parking rates		parking volume	short-term parking increased	
20. Employer Parking Pricing and Supply Actions				
Cash out		solo driving	24% reduction	Los Angeles central city areas
Charge federal employees for parking		commuting trips	1-10% reductions	
Charge federal employees for parking		solo driving	21% reduction	Ottawa
Charge market rates for parking		solo driving	12% reduction	
Parking pricing		solo driving	17% reduction	Bellevue City Hall
Parking pricing		solo driving	25% reduction	CH2M Hill
Parking pricing		solo driving	25% reduction	20th Century Corp.

Table 3-2

Summary of Transportation Control Measure Effectiveness (continued)

Measure	Effective Period	Measure of Effectiveness	Level of Effectiveness[1]	Observed Locations
Parking pricing		solo driving	55% reduction	U.S. West Bell
Parking pricing		solo driving	34% reduction	Commuter Computer
21. Employer-Based Rideshare Programs		solo driving	various reduction rates	various U.S. locations
22. Variable Work Hours				
Staggered hours		travel time	10% reduction	downtown Honolulu
Compressed work week		solo driving	5% reduction	Ventura County
23. Telecommuting				
Telecommuting programs	daily	work trips	30% reduction	State of California
Telecommuting programs		fuel consumption	29% reduction[2]	C&C Honolulu
24. Transportation Management Associations (TMA)				
TMA actions		solo driving	3% reduction	Hartford
TMA actions		solo driving	5% reduction	Irvine, Orange County
TMA actions	peak time	solo driving	35% reduction	Hacienda Business Pk.
25. Trip Reduction Ordinances		solo driving	various reduction rates	various U.S. locations
26. Actions by Educational Institutions				
Starting school day 1 hour later		travel time to Primary Urban Center (PUC) areas	15-20% reduction	Hawaii

Table 3-2

Summary of Transportation Control Measure Effectiveness (continued)

Measure	Effective Period	Measure of Effectiveness	Level of Effectiveness[1]	Observed Locations
27. Pricing or Other Control of Automobile Use				
Road pricing	peak time	traffic volume	40% reduction	Singapore
Road pricing		traffic volume	20% reduction	Hong Kong
Road pricing		auto trips	28% reduction	to Stockholm City
Road pricing		auto trips	6% reduction	Stockholm County
Road pricing		vehicular speeds	30% increase	Stockholm C&C
Road pricing		traffic volume	37% reduction	London
Road pricing		auto trips	10-20% reductions	Boston, NYC
Road pricing		auto trips	10-20% reductions	SCAG
28. Land Use Patterns and Energy				
Good accessible design		vehicle mile traveled	30% reduction	New Jersey

Source: Wilbur Smith Associates, May 1992.

Notes:
1) Effectiveness is typically restricted to a travel corridor or other locations. Effectiveness is also highly specific to the details of the program being evaluated typically.
2) In one office.

- Public transit marketing;
- Paratransit-premium subscription express bus service;
- Paratransit-shared ride taxi;
- Guaranteed ride home;
- Areawide rideshare programs;
- Controls affecting parking supply;
- Pricing actions affecting parking;
- Employer parking pricing and supply actions;
- Employer-based rideshare programs;
- Variable work hours (includes variable work weeks);
- Telecommuting;
- Transportation management associations;
- Trip reduction ordinances;
- Actions by educational institutions;
- Pricing or other control of automobile use;
- Land use patterns; and
- Energy-saving effectiveness of the identified TSM measures.

When considering the energy consequences of TCMs, several factors must be recognized. First, TCMs were not developed to reduce energy demand. In general, they were developed to increase mobility and reduce air pollutant emissions. Other goals of TCMs are to increase capacity or reduce traffic congestion. While relieving congestion could intuitively suggest decreasing energy demand by decreasing travel time and affecting average speed (for a more complete discussion of the effects of congestion on energy demand, see Section 3.1), some TCMs could actually increase energy demand. For example, bus priority measures (see Section 3.4.2.10) could decrease levels of service for SOVs by increasing their waiting times at intersections. Net energy effects could be positive or negative, depending on the specifics of the situation.

Even when a TCM does not work directly against energy conservation, TCMs could indirectly increase energy demand by improving system operations, thereby encouraging SOV use and generating additional trips.

Since congestion is frequently caused by localized traffic choke points, many TCMs are designed to address the bottleneck. Their effects are spatially and/or temporarily localized and they have no effect on total regional vehicle miles traveled (VMT). For example, measures to decrease peak travel demand, such as staggered work hours, have no effect on total regional VMT over a 24-hour period, and therefore have a minimal impact on energy demand. However, if the TCM succeeds in reducing localized congestion over the long term, some energy savings may be achieved.

In summary, TCMs were designed to affect travel performance. Energy saving could be a by-product, but is not usually a primary goal.

The effectiveness of TCMs is best predicted by running traffic models that incorporate detailed, accurate, validated input parameters. There are very few such modeling studies for Hawaii that are readily available, regionally applicable and produce data that could be directly entered into an energy saving calculation. Therefore, the approach followed in this project is primarily to qualitatively discuss TCM effectiveness, and where possible, summarize quantitative estimates from selected studies. (See, for example, section 3.5 which reports some results based on traffic modeling for combinations of TCMS.)

The Oahu Metropolitan Planning Organization (OMPO), a state and County organization responsible for coordinating transportation planning efforts on Oahu, began a study to develop TCM recommendations for Oahu in November, 1991. The first phase of the study, an initial screening of both supply-side (TSM) and demand-side (TDM) actions, concluded with the 28 TCMs listed at the beginning of this section in the Transportation Systems Management Study: An Interim Working Paper Initial Screening of Actions (Wilbur Smith Associates, 1992). In July 1992, 6 of the 28 actions were chosen by the OMPO Policy Committee to be more closely studied. These six TCMs were:

- preferential bus treatments;
- private premium bus service;
- jitney services;
- parking supply controls;
- alternatives to employee parking subsidies; and
- educational system actions.

In January 1994, 17 of the original 28 actions were endorsed by the OMPO Policy Committee. Currently, these 17 actions have been forwarded to the appropriate state, City and County, and private agencies for review. The 17 that have moved forward are:

- HOV lanes;
- expansion of TheBus service capacity;
- control of parking supply;
- reduction of employee parking subsidies;
- educational system actions;
- telecommuting and teleconferencing;
- park-and-ride facilities;
- guaranteed ride home;
- variable work hours;
- transportation management associations;
- areawide rideshare program;

- jitneys;
- land use provisions;
- premium subscription bus services;
- road pricing;
- trip reduction ordinance; and
- vehicle use limitations.

Starting in December 1992, the Transportation Committee of the City Council also sponsored a planning process of TSM measures through its Transportation and Traffic Management Task Force. This Task Force has produced a report which focuses on increasing the efficiency of present transportation facilities through expanding public transit and TSM measures. This report recommends increasing the use of HOV lanes, especially in the urban area. The energy consequences of the TSM measures are not explicitly addressed in this report, however.

3.4.2 TRANSPORTATION CONTROL MEASURES PROPOSED FOR OAHU

The purpose of this section is to describe in more detail many of the measures that have been suggested to help alleviate Honolulu's traffic congestion problems. An attempt is made to close the discussion of each TCM with an assessment of its potential to affect regional VMT, and thereby achieve energy savings.

3.4.2.1 Operational Modifications To Improve Traffic Flow

Operational modifications increase capacity, thereby alleviating congestion, improving traffic flow, reducing travel times and, to some degree, reducing energy wasted in congestion. Such improvements could be implemented without the impacts or costs associated with major reconstruction or widening projects. Such actions include:

- *Conversion of two-way streets to one-way operation:* Under specific circumstances, this technique has increased capacity 10 to 20 percent above two-way operations (Wilbur Smith Associates, 1992). Conversion could increase VMT slightly due to the more circuitous routes which are sometimes required when utilizing a network of one-way streets.
- *Reversible and contra-flow lanes:* The increase in capacity resulting from reversible or contra-flow operation is generally proportional to the change in number of lanes.
- *Curb lane parking restrictions:* This technique could provide increased capacity equivalent to the increase in the number of lanes. Parking restrictions also improve bus travel times.
- *Traffic signal interconnection and coordination:* This measure could improve travel times by 10 to 20 percent or more on the favored streets, and could also produce small increases in vehicular capacities. Services could deteriorate on streets which are not favored by the synchronization.

State Department of Transportation (SDOT) and Department of Transportation Services (DTS) have implemented many such roadway operational improvements, such as contra-flow lanes on Kalanianaole Highway and Kapiolani Boulevard, one way operation on Punchbowl and other downtown streets, signal synchronization of 290 intersections in the Downtown area and curb lane parking restrictions on several streets.

Because each of these actions generally improve traffic flow and reduce delays, they can actually encourage SOV usage and stimulate additional trips. Energy conservation effects could thus be offset by additional travel induced by improved system performance. In addition, with these types of measures, improvements are highly localized. Adjacent areas could actually experience deterioration in service when some street system modifications are implemented.

The effect of this TCM on regional VMT and therefore energy demand would be minimal.

3.4.2.2 Intersection And Roadway Modifications

Intersection geometries and traffic characteristics sometimes produce operational problems. Some could be mitigated by localized physical or operational modifications. For example:

- *Addition of left-turn lanes to provide a stacking area; prohibition of left-turn movements; and separate left-turn phases at signals*: These measures could reduce queuing and delays by 20 to 30 percent for left-turn vehicles that would otherwise experience long waits for gaps in opposing traffic.
- *Construction of raised islands and corner rounding:* This technique could improve intersection capacity by increasing speeds through the intersection.
- *Modified traffic signal phasing and timings to most efficiently accommodate traffic patterns:* This technique is similar to one described in Section 3.4.2.1., but adds variation in the synchronization pattern where traffic characteristics change substantially through the day.
- *Pullouts at bus stops so that stopped buses do not block through traffic:* This geometric improvement could eliminate delays caused by stopped buses blocking traffic lanes, significantly increasing the vehicular capacity of the roadway. Buses could experience delay in reentering the travel lanes.

Localized roadway modifications such as those described above are numerous in Honolulu and are regularly implemented through City and state programs, and traffic impact mitigation requirements placed upon developers. As only one example, bus pullouts recently installed on Kapahulu have substantially increased the capacity of this road.

The effect of this TCM on regional VMT and energy demand would be minimal.

3.4.2.3 Freeway Operations

Several operational strategies could be implemented to maximize existing highway capacity. For example:

- *Ramp Metering:* This measure improves traffic flow on freeways by relocating delays to the on-ramps, and discouraging use of the freeway for short trips. Effectiveness depends on the severity of congestion and specifics of the metering program. Ramp metering could result in 30 percent increases in peak period travel speeds, 20% increases in traffic volumes and 10 to 40 percent decreases in travel times (Wilbur Smith Associates, 1992).

- *Ramp Closures:* As an extreme form of ramp metering, entry prohibitions to the freeway could be implemented on a selective basis, such as during peak periods. The closure of heavily used ramps during peak periods, which could result in increased travel time and inconvenience for affected motorists, could be highly effective in increasing transit use. Partial closures, which limit ramp use to buses or other HOV, are also very effective.
- *Use of Shoulder Lanes:* This technique is a low cost measure to quickly increase highway capacity during an interim period. Such lanes are created from the existing paved shoulder. Additional lanes can also be provided in some situations by reducing the width of the through lanes. Although travel speeds and safety could be adversely affected, these aspects could be partially mitigated by proper signage, enforcement, and the construction of turnouts to store disabled vehicles.

With federal approval, state government could implement improvements in freeway operations. The feasibility of ramp metering in Honolulu was studied for the H-1 Freeway in the late 1970s as part of a state-sponsored evaluation of traffic surveillance and control systems, geometric modifications, intersection improvements, signal system improvements, and preferential treatments for bus transit. However, ramp metering has not been implemented because of concerns about adequate queuing areas at on-ramps, and insufficient capacity to accommodate the traffic diverted from the freeway on alternate routes.

The effect of this TCM on regional VMT and energy demand would be minimal.

3.4.2.4 Roadway Enforcement And Management

Roadway enforcement and management includes not only freeway operation strategies (ramp metering, ramp closure and use of shoulder lanes) that were discussed above, but also incident management systems, diversion and advisory signage, surveillance, control and enforcement. The emphasis here is on unpredictable incidents caused by accidents or bad weather. Reducing delays caused by such incidents could save energy.

Incidents are managed by such measures as:

- pre-positioned or roving tow trucks;
- closed circuit TV at key intersections and freeway sections;
- variable message signs advising the use of alternate routes;
- aerial surveillance (traffic helicopters);
- roadside call boxes; and
- a control center staffed to provide traffic engineering and police coordination for quick incident response.

These strategies help maintain capacity through the timely clearance of the capacity-limiting incident, and/or by controlling and rerouting traffic during the incident. A 1986 FHWA study

(Wilbur Smith Associates, 1992) indicated that incident management systems could reduce congestion on approximately 30 percent of major urban area highway mileage. For example, a program in Boston produced an increase in speeds on the affected arterial, and corresponding travel time reductions of over 30 percent. VMT were not reduced, but vehicle hours of travel was reduced by 5 percent. Such a reduction in vehicle hours might save energy.

State and City agencies have enforcement and incident management programs (e.g., Capt. Irwin), and additional programs are being implemented, such as the variable traffic message signs proposed for deployment at 50 locations around Oahu.[5]

Types of traffic enforcement that maintain flow include:

- enforcement of intersection blockage restrictions to avoid gridlock;
- enforcement of "no parking" and "no standing or stopping" restrictions;
- enforcement of left-turn restrictions; and
- enforcement of HOV lane usage.

Such measures help prevent and ease congestion.

The effect of this TCM on regional VMT and energy demand would probably be minimal.

3.4.2.5 Vehicle Use Limitations

Vehicle use limitations are designed to discourage vehicles, particularly SOVs and trucks, from entering congested areas during peak periods by increasing costs and decreasing convenience. The desired public response would be shifts to alternative travel modes, like HOVs, walking, bicycling or avoidance of the peak period. Because these measures are disincentives and decrease traveler convenience, their implementation could be controversial. Examples include:

- *Auto-restricted zones:* Such zones restrict traffic from certain streets or precincts temporarily or permanently. Singapore's Area Licensing Scheme (ALS), which limits the automobiles entering the Central Business District (CBD), is a well-known example of a vehicle use limitation strategy. Morning peak access to the CBD is restricted to vehicles with special licenses purchased at a premium fee, and vehicles with three or more occupants. The program resulted in a significant shift of travelers from auto to transit. The measure has also resulted in staggered work hours so that some portion of the commuters avoid the peak period. Similar programs in Boston reduced traffic volumes in the downtown restricted zone by 5 percent, mainly due to a shift in travel mode (Wilbur Smith Associates, 1992).
- *Pedestrian malls:* Street closures in downtown Honolulu have been implemented to create pedestrian and transit malls (e.g. Fort and Hotel Street malls).

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[5] Deployment of the signs is causing controversy for several reasons, such as perceptions of visual intrusion and lack of options in response to certain messages.

- *Time restrictions on truck deliveries:* Such measures prohibit truck deliveries during peak periods.
- *Gas rationing:* This severe measure would regulate VMT by regulating the supply of energy.
- *Restricted travel days:* This measure restricts travel on certain days (e.g., odd-, even-travel days).

To maximize effectiveness and political palatability, these disincentives must be accompanied by enhancing alternatives to SOV travel, such as preferential treatment for transit, express buses, park and ride lots, and other measures that enhance HOVs.

Government could implement restricted zones on Oahu. The areas most commonly mentioned for implementation of an ALS are Downtown and Waikiki. Implementation issues include the adequacy of transportation alternatives, provisions for residents' vehicles and tourist rental cars, the days and hours that the restrictions would be in effect, details of the cost structure, and the logistics of revenue collection.[6] However, because of the controversial nature of such a restriction[7] and difficulties associated with enforcement, this TCM is generally viewed as a last resort.

The effect of this TCM on regional VMT and energy demand could be substantial, depending on details of implementation.

3.4.2.6 High Occupancy Vehicle (HOV) Facilities

Such facilities provide priority to HOVs (e.g., buses, car-pools, and van-pools) by designating lanes, ramps, parking and other facilities for the exclusive use of HOVs during selected hours. HOV facilities increase a travel corridor's people-moving (versus vehicle-moving) capacity. Such facilities improve the service provided by HOVs to make them more competitive with SOVs. Sometimes the HOV improvements are made at the expense of SOVs (e.g. turning mixed traffic lanes into "diamond" lanes).

HOV facilities could be located on freeways or other roads, and can also be dedicated transitways or busways. A recent suggestion is "electric bus flyovers," HOV ramps dedicated to electric buses (Hendrickson, 1993).

The effectiveness of HOV lanes is typically measured by travel time savings. Recent studies (Wilbur Smith Associates, 1992) indicate that the most successful HOV lanes carry three times as many people as a conventional lane. HOV lanes are most effective in dense urban cores with high levels of existing transit/car-pool use, and are much less effective in less densely

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[6] Under the original scheme in Singapore, automobiles entering the CBD went to booths where licenses were purchased. Such a technique requires the deployment of collection booths with sufficient queuing area. A "high-tech" improvement to this scheme could be feasible wherein automated detectors would individually identify vehicles passing a checkpoint, and a monthly bill for access to the restricted area would be generated periodically. Such a system would enable implementation of a complex, time-of-day-sensitive rate structure.

[7] Implementation of an ALS in Honolulu is currently a heated topic in the press and elsewhere. ALSs can be viewed as highly regressive, a concern that has spawned numerous rebate schemes to lessen their regressivity. The adequacy of viable transportation alternatives in Honolulu, should an ALS be implemented, is also a concern. However, the most recent Waikiki master plan includes a people-mover system, which would provide an alternative to vehicles for trips made within Waikiki.

developed areas. The nature of the enforcement (keeping SOVs out of HOV facilities) also has an impact on HOV usage and effectiveness.

HOV lanes could reduce fuel consumption and emissions. However, if SOV use increases as an indirect effect of HOV incentives, these reductions could be nullified.

The Oahu Regional Transportation Plan (RTP) (OMPO, 1991) describes major expansion plans for the HOV network, from the existing 14 miles in 1991 to 35 miles by the year 2005. SDOT is widening the H-2 Freeway between Mililani and the Wahiawa Interchange to add an HOV lane in each direction, and is also planning for HOV facilities on Nimitz Highway between Keehi Interchange and Pacific Street.

The effect of this TCM on regional VMT could be significant, but resultant improvements in SOV service could generate additional travel.

3.4.2.7 Smart Transit (Smart Street/Vehicle Concepts)

The purpose of Intelligent Transit, also known as Intelligent Vehicle/Highway Systems (IVHS), is to improve roadway performance through state-of-the-art electronic technology and control software. There are four basic categories of IVHS, each with a different application.

- *Advanced Traffic Management Systems (ATMS):* These systems allow quicker incident response through the use of real-time traffic monitoring techniques, areawide surveillance and detection, and integration of a number of freeway operation techniques and increase efficiency of the highway system.
- *Advanced Traveler Information Systems (ATIS):* These systems provide drivers with audio or visual information on congestion, alternate routes, navigation, and roadway conditions.
- *Commercial Vehicle Operations (CVO):* These systems improve the safety and productivity of commercial vehicles through faster dispatching, more efficient routing, hazardous material tracking, and reduced administrative costs.
- *Advanced Vehicle Control Systems (AVCS):* These systems improve safety and increase highway capacity by providing information about changing road conditions, and then using that information to adjust the vehicle's movement.

Each of these technologies is currently under various stages of development and testing. Some major vehicle manufacturers are proposing to install ATIS systems in just a few model years.

Based on a Smart Corridor demonstration project in Los Angeles, it was estimated that the combined use of ATMS/ATIS might reduce congestion and delay times between 20 and 40 percent (Wilbur Smith Associates, 1992).

Application of IVHS-type technology on Oahu is under discussion, and ATMS are being implemented as part of the H-3 project. A project to develop a master plan for IVHS on the island of Oahu is underway. Funding of additional IVHS applications is being sought.

The effect of this TCM on regional VMT is probably minimal.

3.4.2.8 Bicycle And Pedestrian Facilities

Programs promoting bicycles and walking as alternative transportation modes typically include the following:

- a clearly designated circulation network linking residential areas with major destinations, such as employment centers, universities, or transit centers;
- safe storage facilities for bicycles at destinations;
- access to convenient, comfortable showers and clothing lockers at destinations; and
- safety amenities such as lighting, barriers, grade-separations, signal preemption, etc.

Bicycle facilities have been constructed throughout the country. Bicycles and walking as alternative transportation modes are particularly popular in university or college-oriented communities.

The ability to transport bicycles on transit vehicles or other HOVs can also be important.

If a system of connected bike paths and sidewalks were available that would be separated from streets, people would be more willing to walk or bike to work, transit stops or shops. Providing facilities for pedestrians, such as paths, crosswalks, benches, landscaping, and fountains, would encourage more trips to be taken by walking rather than by driving. Furthermore, people generally walk farther in a quality pedestrian environment.

On a national average, sixty percent of all vehicle trips are less than five miles (Wilbur Smith Associates, 1992). If 5 percent of these trips could be diverted from cars to bicycles, 3 percent of all personal vehicle trips and 1 percent of all personal VMT and gasoline consumed could be eliminated. Nationally, 7 percent of vehicle trips to work and 11 percent of non-work vehicle trips are less than 1/2 mile (Wilbur Smith Associates, 1992). If 20 - 50 percent of these trips were made by walking rather than driving, overall vehicle trips could be reduced by 2-5 percent, and gasoline consumption reduced by about 1 percent. For every 100 short trips that could be diverted from a car to walking or bicycling, 5-26 gallons of gasoline could be saved, assuming an average of 19 miles per gallon and trips ranging from 1 to 5 miles long.

Certain urban areas in other countries have much greater bicycle use than is typically found in the United States.

Bicycles and walking could also serve as a home and/or work-based feeder mode to a transit stop or center.

Although State of Hawaii, Department of Transportation's 1977 Bikeplan Hawaii: A State of Hawaii Master Plan proposed a 248-mile long bikeway system on Oahu, only about 40 miles have been implemented to date. SDOT revised the bicycle plan in 1994.

In spite of bicycling's potential, the impact of increased bicycle use on automobile travel is viewed as limited due to longer travel times, limited travel range, safety concerns, weather and geographic restrictions, and other factors. Studies in Phoenix, Detroit, and Los Angeles have indicated that about 1 percent of all trips between 1 and 3 miles in length might shift to a bicycle mode in response to inducements (Wilbur Smith Associates, 1992). Depending on the success in implementing a much more extensive bikeway system in Hawaii, the level of interest in bicycling in this state suggests that Hawaii could achieve a greater degree of modal shift to bicycles than areas on the mainland. Consequently, from an energy perspective, the state should pursue its bikeway program. However, the effect of this TCM on regional VMT and energy demand is probably limited.

3.4.2.9 Public Transit Expansion

Oahu

Major transit improvements proposed for Oahu have included:

- expansion of TheBus system;
- a fixed-guideway rapid transit system (Honolulu Rapid Transit); and
- development of a water transit system with terminals along the south shore of Oahu between Hawaii Kai and Barbers Point.

Each of these will be discussed in turn.

Existing transit service on Oahu consists of two systems: TheBus and the HandiVans. Both are under the administration of the Honolulu Public Transit Authority (HPTA), which contracts with private firms to operate each system. TheBus greatly exceeds the HandiVan in terms of fleet size, total route miles, passenger miles, and energy consumption. At present, TheBus consists of 493 buses which travel an islandwide network and are maintained and serviced at two facilities, the Halawa facility, which has capacity for 200 buses, and the Kalihi Palama facility, which has capacity for 250 buses. Local and express services are provided. Annual system ridership is about 73 million unlinked rides, and the system is one of the most highly utilized in the country with 18.2 riders per system mile.

Expansion of the system is largely financially constrained. A study is presently underway which is defining the 5-year capital improvement program for the system. Developing a third bus maintenance facility is the major constraint to system expansion. TheBus recently received 93 new buses, but most of these were used to retire old equipment rather than increase the size of the fleet.

As an immediate response to the demand for additional bus service, HPTA has contracted with private companies for a number of express bus routes to Central and Leeward Oahu.

Expansion of TheBus is consistent with a future rail transit system. If a fixed-guideway system were built, bus routes could be reconfigured to support the fixed guideway system.

Energy savings associated with one scenario of improvements to TheBus system are discussed below. However, apart from energy demand considerations, TheBus is already playing a role addressing Hawaii's energy issues through its participation in the Hawaii Electric Vehicle Demonstration Project (HEVDP). TheBus will be operating a hybrid electric/propane vehicle on the No. 4 route. It should also be noted that the HandiVan system, the smaller existing transit system on Oahu, uses propane.

Energy savings associated with one scenario of improvements to TheBus system are discussed below. However, apart from energy demand considerations, TheBus is already playing a role addressing Hawaii's energy issues through its participation in the HEVDP. TheBus will be operating a hybrid electric/propane vehicle on the No. 4 route.

Planning for a fixed-guideway rapid transit system on Oahu has been ongoing, with some interruptions, for the past 30 years. The system was initially known as Honolulu Area Rapid Transit (HART). Planning of HART occurred from 1977 to 1981, but ceased during the 4-year administration of a rail transit opponent. Planning resumed again in 1986, when the system was renamed Honolulu Rapid Transit (HRT). The HRT proposal had successfully completed the environmental review process, and over $700 million in federal funds were committed to the $1.9 billion project, when the City Council was unable to agree on a local funding source. The project is at present stalled, but attempts to resurrect it could be expected.

Recent studies (1991 and 1992) conducted for the HRT provide data that may be used to analyze the energy consequences of two scenarios of transit improvements. These two scenarios have been analyzed against a future baseline condition that assumes no improvements are made to the transit system on Oahu.

The first scenario assumes that improvements are limited to TheBus. The specific improvements are:

- a bus fleet of 964 vehicles;
- 803 vehicles operating during peak travel periods;
- 8 park-and-ride lots (about 250 parking stalls each);
- express service from park-and-ride lots to activity centers, such as Downtown/Kakaako, the University of Hawaii, and Pearl Harbor; and
- 4 to 6 bus maintenance and/or storage facilities.

The second scenario assumes that the HRT system is built, including the provision of a feeder bus system to the transit stations.

Table 3-3 shows a very approximate comparison of the energy consequences of these two transit options in the year 2005. Table 3-3 shows that both transit improvement scenarios would decrease automobile and passenger truck VMT substantially. The rail transit alternative would be over twice as effective as the all-bus option in reducing this category of VMT. Reductions in energy use would be proportionate.

Savings, however, would be somewhat offset for the all-bus alternative by increases in bus VMT, and for the rail transit alternative, the energy required to run "TheTrain." For the all-bus alternative, the energy required for increased bus VMT would be slightly less than the energy saved through reduced auto and passenger truck VMT, indicating that the all-bus alternative

Table 3-3

Changes in 2005 Energy Consumption Due to Transit System Improvements on Oahu

	Future Baseline	Transit System Improvements	
		All-Bus	**Rapid Transit/Bus**
Change in Annual Auto and Passenger Truck VMT	N/A	-57,400,000	-162,000,000
Change in Annual Auto and Passenger Truck Gasoline Consumption (barrels)	N/A	-63,900	-180,000
Change in Annual Auto and Passenger Truck Energy Consumption (billion BTUs)	N/A	-310	-870
Change in Annual Bus VMT	N/A	6,130,000	-2,810,000
Change in Annual Bus Diesel Consumption (barrels)	N/A	37,400	-17,200
Change in Annual Bus Energy Consumption (billion BTUs)	N/A	200	-92
Rail Transit Electrical Energy Consumption (billion BTUs)	N/A	N/A	670
Annual Ground Transportation Energy Consumption (billion BTUs)	72,000	71,000	71,000
Change in Annual Ground Transportation Energy Consumption (billion BTUs)	N/A	-110	-300
Percent of Future Baseline Ground Transportation Energy Consumption	100%	99.8%	99.6%

Sources: City and County of Honolulu, Department of Transportation Services, July 1992; Parsons Brinckerhoff Quade and Douglas, Inc., 1994.

Notes:
1) Auto and passenger truck VMT reductions calculated from data presented in the Honolulu Rapid Transit Program Transportation Impacts Results Report, July 1992.
2) VMT reductions taken from automobile and passenger truck classes in proportion to the VMT in each class.
3) Bus VMT changes from Honolulu Rapid Transit Program FEIS, Table 4.1, with the Future Baseline defined as the No-Build Alternative designed to accommodate peak-load-point demand with the same vehicle load standards as the other alternatives (see Footnote 1, Table 4.1). Annual revenue vehicle miles are multiplied by 1.147 to account for non-revenue mileage.
4) Rail transit energy consumption taken from Honolulu Rapid Transit Program FEIS, Section 5.9.
5) Gasoline energy consumption converted to BTUs at a rate of 115,000 BTUs per gallon.
6) Diesel energy consumption converted to BTUs at a rate of 128,000 BTUs per gallon.
7) Electrical energy consumption converted to BTUs at rate of 11,097 BTUs per kilowatt hour.

would save energy, though not a lot. For the rail transit alternative, the energy demand of TheTrain would also be less than the energy saved through reduced auto, passenger truck and bus VMT.

Therefore, based on energy balance calculations, both all-bus and bus-rail transit would save energy, but only slightly. It is important to note that, because of the large power demand of TheTrain, the energy balance results are quite sensitive to the assumed energy consumption efficiency rates. An increase in electrical energy production and transmission efficiency from an assumed current level of 30 percent to a future level of 35 percent would increase energy savings.

However, in contrast to the above analysis which suggests that transit has little impact on gross energy demand, other analyses performed by OMPO suggest that transit, in combination with some roadway improvements to "core" transportation corridors in Honolulu, could produce an energy savings by the year 2020 on the order of eight percent. This analysis, which is based on a combination of transit and roadway improvements, is discussed in more detail in Section 3.5.

In spite of limited energy savings, however, TheTrain alternative could substantially reduce the use of liquid fuel, and replace it with electric energy which could be produced by a variety of fuels. In fact, the very approximate match of "TheTrain's" power requirement and the capacity of Honolulu Project of Waste Energy Recovery (H-POWER) resource recovery facility, plus the observation that the H-POWER facility would be dispatched to meet only peak requirements during the commuting period led to the concept that TheTrain would be "powered by garbage," thereby displacing petroleum. While somewhat misleading, this phrase does point out that, even though rail transit may not generate substantial energy savings, it could potentially displace petroleum in favor of other fuels which could be utilized to make electricity. Such fuel substitution alone would help to achieve Hawaii energy goals. A similar effect could occur with the use of electric buses.

Transit is also almost unique among the TCMs (along with land use patterns) in being able to have market share in all travel markets (home to work, home to school, home to shopping, home to recreation, etc.), thereby providing an alternative to SOVs.

In summary, expanding ground transit on Oahu would substantially reduce regional VMT for autos and passenger trucks to levels below where it would otherwise be at in the absence of the improvements. The bus/rail transit improvements would be over twice as effective in reducing auto and passenger truck VMT as the all-bus improvement option, but either option would have substantial effects. However, the energy requirements of either improvement would require much of the energy saved, although transit expansion would save energy. In addition, the rail transit option (and electric buses) could produce substantial petroleum displacement, depending on the fuel utilized to produce the electricity to power the train or buses. It would be in the state's energy interest, then, to promote rail and electric buses, because the effect could be a substantial reduction in petroleum requirements.

Initial planning for a water transit system consisted of seven ferry terminals stretching from Barbers Point Harbor, along the south shore of Oahu, to Hawaii Kai. Because of issues associated with implementation, the sole link implemented to date has been the one between Barbers Point Harbor and Downtown Honolulu, the link that was projected to have the lowest ridership of any in the total system. Limited service was provided on this route in the summer and fall of 1992. The ferry, Sea Jet I, was operated during peak periods. Actual ridership was even lower than the low ridership that was expected, and the service was discontinued.

The ability of a water transit system to attract SOV users and thereby affect fuel consumption is not known. Net energy effects would depend heavily on ridership, and high velocity ferries with relatively small passenger capacities could be more energy intensive per passenger-mile than ground-based modes.

Neighbor Islands

Ground transportation systems on the neighbor islands are different from those on Oahu in several respects, such as:

- the size of the urban center;
- the distance of travel;
- the existing transportation infrastructure; and
- the population density and distribution.

Hawaii and Kauai Counties operate small bus systems at present. The situation for each County is summarized as follows:

- *Hawaii*: The County of Hawaii Mass Transportation Agency (MTA) administers the Hele-On public bus system. This transit system utilizes ten 42-passenger buses and offers seven routes. The frequency of service is quite limited, with service provided Monday through Friday, one route operating on Saturdays, and no service on holidays. The largest of the two primary providers of specialized transportation services for the elderly and the handicapped is the Hawaii County Economic Opportunity Council, which operates twenty-one vans and mini-buses on a fixed schedule. The other is the Elderly Activities Division of the Hawaii County Department of Parks and Recreation which operates seventeen vans on a demand basis. In addition, State Department of Accounting and General Services (DAGS) contracts with private bus companies to provide school transportation presently utilizing 175 buses. There are also numerous visitor transportation services on the Big Island, such as tour buses, airport shuttles and limousines, and hotel and resort shuttles. Service expansion options are under consideration by MTA for the future, as well as a rideshare program in East Hawaii.
- *Maui*: There is no County-operated public transit on Maui. Most of Maui's HOV transportation services are private or non-profit and primarily serve visitors, the elderly and the handicapped, and students. Currently, Maui Economic Opportunity, Incorporated (MEO), a non-profit organization, operates twenty buses. In addition, the DAGS contracts with private bus companies to provide school transportation utilizing ninety-five buses. There are four major tour bus operators on the island. Airport shuttles are also available. Many hotels, separately and cooperatively, offer shuttle and trolley services to their employees from remote parking areas, and other transportation services for workers from Molokai. Based on existing travel demand, plans for future transit on Maui consist of six additional transit routes and four alternative systems.
- *Kauai*: Before Hurricane Iniki, the County provided two transit lines. One route served employee transportation for the Kilauea Agronomics and Esakai Farms, and the other

served a commuter route between Kapaa and Lihue. The County Office of Elderly Affairs operated an islandwide system on a demand basis for the elderly and the handicapped. The program consisted of ten vehicles, two with wheel chair lifts. However, six days after Hurricane Iniki struck, four separate bus companies began emergency services utilizing 10 buses between the primary communities on the island. The temporary bus system, called the "Iniki Express", now operates 13 buses serving 12 residential communities. It also provides a feeder service that connects the line haul routes centered in Lihue. Based on travel demand projections, eight additional bus routes and six transit system alternatives have been developed.

Based on the Oahu analysis reported above, improvements to the transit systems on the neighbor islands would not generate an appreciable energy savings at the state level.

3.4.2.10 Operational Improvements In Transit Service

Efficient and reliable operations increase productivity, cost-effectiveness and attract riders. Operational improvements are generally characterized as service-oriented, roadway-oriented or management actions.

Service-oriented improvements include:

- route and schedule modifications (limited stop and skip/stop operation, altering headways, turn backs, split routes, etc.);
- placement of stops to minimize traffic signal impacts (nearside to farside);
- after-hours "sweeper" services;
- timed transfer hubs to enhance transfer coordination; and
- reduction in number of bus stops.

Roadway-oriented improvements include:

- bus-only lanes which allow buses to bypass congestion;
- elimination of curb parking along bus routes during peak periods; and
- bus-activated signal preemption to improve schedule reliability. (Bus-activated signal preemption is a technology wherein the approach of a bus is detected by the control system of an intersection's signalization — the control system then adjusts signal timing to give the bus "the green.")

An example of a management action to improve transit operations is prepaid fare collection systems.

Improvements in operations can have an impact on corridor-level congestion. Effectiveness depends on a number of factors, including the extent of modal shift from SOVs.

Adjustments and refinements to TheBus' service are ongoing. The transit improvement program for fiscal year (FY) 92 through FY 97 includes an automated vehicle monitoring system, radio system enhancement, and management and information system (MIS) improvements to enhance operations.

The effect of this TCM on regional VMT is not likely to be significant because TheBus is already quite efficient.

3.4.2.11 Park-And-Ride Facilities

The City and County of Honolulu operates four park-and-ride facilities located in Hawaii Kai, Wahiawa, Haleiwa, and Mililani. The Hawaii Kai park-and-ride facility opened for service in August 1988. The park-and-ride facility in Wahiawa is shared with the National Guard Armory. The Haleiwa park-and-ride is also a shared-use facility with the Waialua Association Gym. The Mililani facility, completed in January 1994, is located near the Mililani Interchange. A new exclusive-use park-and-ride facility is presently being constructed on land mauka of Royal Kunia subdivision, in central Oahu. The facility opened in December of 1994. The HPTA is the lead City and County agency responsible for developing park-and-ride facilities. The Capital Improvement Program for TheBus includes development of some suburban park-and-ride lots on land dedicated by developers. Plans for the Honolulu Rapid Transit project also included park-and-ride facilities at selected stations.

Park-and-ride lots could greatly enhance HOV options by providing a central rideshare collection point. Park-and-ride lots could be dedicated exclusively for commuter use (Hawaii Kai) or have a shared use, such as a parking lot for a shopping center. (Under limited parking conditions, shopping center management could object to park-and-ride utilization of its lots. Such a position ignores joint development possibilities--see Section 3.4.2.28.)

It is difficult to isolate the effectiveness of park-and-ride lots since they are often implemented synergistically with other TCMs. Park-and-ride lots, in conjunction with HOV lanes, could result in travel time savings, reduced congestion, increased transit patronage, and increased HOV market share.

The effect of this TCM alone on regional VMT and energy demand is probably limited.

3.4.2.12 Public Transit Marketing

A transit marketing plan is cost-effective, encourages new ridership, makes service information easier to obtain, improves transit's public image, and satisfies other goals provided there is unused transit capacity.

A marketing program is one of the most important programs undertaken by a transit agency. In New York City, a regional transit guide increased ridership and decreased auto use among those who used the guide (Wilbur Smith Associates, 1992).

The Island-Wide Comprehensive Bus Service Plan (Wilbur Smith Associates, 1988) included a detailed marketing plan. It was recommended that TheBus' marketing budget be increased by 50 percent to fund an expanded marketing program. Currently, TheBus sponsors the Bonus Program, which enables companies to subsidize monthly bus passes for their employees.

The effect of this TCM on regional VMT could be significant but only if it is accompanied by system expansion.

3.4.2.13 Paratransit - Premium Subscription Express Bus Service

Paratransit is generally used to describe a broad range of transportation services other than conventional public-sponsored fixed-route transit services. Paratransit strategies are often applied to lower density travel corridors, areas with dispersed travel patterns, or special travel markets.

Premium subscription express buses (also buspools and club buses) typically provide service between suburban communities and large employers or employment centers. This service differs from conventional express buses in that it is private and serves an identified group of riders who generally subscribe to long-term service. Amenities could also be offered. Premium subscription express service could be coordinated with the service being provided by conventional express buses, or provide a "premium" service in a high-demand corridor that already has conventional express buses.

Premium subscription express bus services could increase HOV market share at the expense of SOVs. Premium subscription express bus service could achieve travel times that are competitive with the auto, particularly if HOV lanes could be used to bypass SOV congestion, and could cost less than auto usage. Premium bus service (and ridesharing in general) could reduce expensive peak demands on public bus systems, energy consumption and pollution, and pressure to expand fixed routes into low density areas.

TheBus provides express routes to many outlying residential communities on Oahu from Downtown and/or the U. H. Manoa area. Supplemental express routes are being provided by private contractors, for example, the TransHawaiian Commuter Express, a luxury commuter bus offering service to residents of Leeward and Central Oahu.

The effect of this TCM on regional VMT and energy demand is probably limited.

3.4.2.14 Paratransit - Jitneys

Jitneys provide an urban transportation service with characteristics common to both shared-ride taxis and local fixed route buses. Private operation, small vehicles and flat fares are its defining characteristics. Jitneys typically operate along fixed routes in high density urban areas at unscheduled (usually short) service frequencies. They are typically small vehicles (5-20 passengers) and stop when hailed. Jitneys should not be confused with shared-ride taxis, which have distance-based fares.

Jitney service is a paratransit strategy that meets specialized needs. Jitneys could work effectively in lower density interurban areas. Applications include areas without bus service, a substitute service on routes marginal for buses, and a supplemental service along shorter, high-demand segments.

Provided jitneys operate on short headways, they could significantly improve overall travel times. Case studies in the United States indicate that jitneys could provide more frequent and faster services than public transit, in the limited market that they serve (Wilbur Smith Associates, 1992).

A recent OMPO-sponsored study on jitney service on Oahu (Wilbur Smith Associates, 1993c) estimated that if extensive jitney service were established on Oahu, with service being provided only during the peak commuting periods, a vehicle occupancy rate of 1.2 could be obtained. This would be about 0.15 percent of the daily traffic, and 0.5 percent of the peak hour traffic on Oahu. This level of potential benefit, which does not include the additional volumes that would be associated with new jitney movements, would probably not yield perceptible energy savings.

Jitney service in Waikiki has been discussed. The high frequency of stopped jitney vehicles pulling into traffic is perceived as an adverse rather than positive effect on overall traffic flow. Jitney services in Waikiki would compete with transit.

Because jitneys could serve only a limited share of the total travel market, the effect of this TCM on regional VMT and energy demand is probably limited.

3.4.2.15 Paratransit - Shared Ride Taxi

Shared-ride taxis provide a demand-responsive service where two or more unacquainted individuals on different trips share a common vehicle. The concept makes more efficient use of the vehicle which can be passed on in the form of lower passenger fares. The principal difference between shared-ride taxis and jitneys are in the nature of the passenger interface and routing flexibility.

Shared-ride taxis operate on a flexible schedule, as opposed to car-pooling or van pooling, which are scheduled. Shared-ride taxis may be used to provide feeder service to transit stops.

Depending on the specific circumstances, the productivity of a shared-ride taxi can be from 50 to 100 percent higher than a single ride taxi. Shared-ride taxis are significantly more fuel efficient and economical on a per passenger basis than underutilized buses.

A small-scale shared-ride taxi service was initiated in Hawaii around 1990 under the Entrepreneurial Services Program of the Urban Mass Transportation Administration. The one-taxi operation provided collection and distribution service between Mililani Town and a park-and-ride lot. The service was short-lived due to lack of patronage.

The total impact of shared-ride taxi services on regional VMT and energy demand is likely to be small.

3.4.2.16 Guaranteed Ride Home

Guaranteed Ride Home (GRH) programs provide carpool and van-pool patrons with a ride home or to other destinations in an emergency. The intent of the program is to overcome a barrier to ridesharing — the need to get to home, to school, to a day-care center or to another location in an emergency.

The guaranteed trip could be provided through fleet vehicles, short term auto rentals or taxi services. The program is most often offered by employers synergistically, as part of a program encouraging car-pooling, transit, walking and cycling.

Effectiveness of GRHs depends on how much the GRH is pivotal in affecting mode choice. It could promote SOV to HOV switching. It could cause some transit users to shift to car-pools, since the program removes the uncertainty car-pool patrons could have about getting to emergencies. Reduction in energy use would depend on the effectiveness of the program in increasing HOV market share, and reducing regional VMT.

The Leeward Oahu Transportation Management Association (LOTMA) provides a GRH program. LOTMA's GRH program had 124 registered participants in March, 1994. To register for the GRH program, the applicant must be a monthly subscriber of a premium subscription bus service. If an emergency arises, the participant of the GRH program contacts their supervisor, who calls a cab company affiliated with the GRH program to drive the participant to the desired location. The cab company is paid with a GRH program voucher. Three vouchers per year per participant are allowed. The program appears successful in that it has attracted to transit commuters who would otherwise most likely be using SOVs. It is expected to continue.

The effect of this TCM on regional VMT and energy demand is unclear, but probably small.

3.4.2.17 Areawide Rideshare Programs

Areawide rideshare programs encourage regional car-, van-, and bus-pooling through computerized matchlists of potential participants, personalized matching services, and focused informational and marketing campaigns. Rideshare programs have taken many forms. They are staffed, funded and/or coordinated by transportation agencies, planning organizations, transit operators, government agencies, and non-profit agencies.

Areawide ridesharing programs best address trips between home-and-work in urban areas of 50,000 or more. Because ridesharing programs target the commuter market, which accounts for about one-quarter of all trips made in urban areas, the impact on regional VMT could be significant. However, recent studies suggest that the market penetration of areawide ridesharing may be relatively limited (Wilbur Smith Associates, 1992).

SDOT's Rideshare Hawaii Program promotes ridesharing during peak hours. Participants contribute to gas and parking expenses, or take turns driving their own cars. The SDOT ridesharing program currently has fifty participants on the database. However, due to a larger number of interested riders than drivers, the majority of program participants cannot be matched to drivers. LOTMA and the County of Hawaii have also been matching carpools for a number of years. The University of Hawaii's Commuter Office, the Waianae Good Neighbor Share-A-Ride program, and Vanpool Hawaii are other carpool matching and vanpool programs on Oahu. The small number of actual participants ridesharing together is expected to have a minimal impact on VMT.

Through FHWA, software and hardware will be purchased to be used by organizations on Oahu and the Counties of Hawaii, Maui and Kauai which organize carpool matching. The software program will enable the organizations to match carpool partners according to their work schedule, place of work or destination, residence and other locations. The software will be hooked up to a mapping program allowing interested people to find out whether co-workers or community members have signed up for carpooling. The software will also make it possible to register and match car-poolers to such events as public meetings or trade shows. As soon as the software equipment is installed, Kauai and Maui will begin providing carpool-matching services to their communities.

The effect of this TCM on regional VMT and energy demand is probably minimal.

3.4.2.18 Controls Affecting Parking Supply

Parking supply controls are designed to discourage SOVs, but sometimes conflict with economic goals. Because of their controversial nature, pricing and supply controls on parking are typically proposed for implementation later, if other strategies have not achieved desired results.

Parking is a critical factor affecting mode choice. Constrained supply and higher prices encourage HOVs. Parking management is most effective when supported by other TSM measures (good transit service, regional rideshare matching, etc.). Because parking strategies are often implemented in concert with other TSM measures, their effectiveness alone is not clear. Cities implementing parking supply reductions in concert with other TSM measures have achieved significant reductions in SOVs.

Parking strategies are best applied in CBDs and other high density areas where land is both costly and scarce, and the parking supply is already constrained. These strategies are less effective in areas of dispersed development and ample parking.

Parking strategies are often implemented with Trip Reduction Ordinances (TROs), which encourage HOV modes (see Section 3.4.2.25).

A recent OMPO study analyzed the effect of establishing maximum parking stall ratios applicable to new office development Downtown and in the Ala Moana-Kapiolani Area (Wilbur Smith Associates, 1993d). The study assumed that limited parking would force commercial institutions to choose between employee and visitor parking. It was assumed that the institution would maintain visitor/customer parking, and forego some employee parking. As a result, when lower parking ratios were applied to proposed new office space, the percent of employees using SOVs was projected to decline marginally during peak hours. The study projected a very slight cumulative impact on area traffic. Under the most severe parking constraint (1 stall to 2,000 square feet), projected traffic in the area could decrease by less than five percent, although it may also result in people driving farther to outlying locations with better parking, thereby increasing VMT.

The effect of this TCM on regional VMT and energy demand is not clear.

3.4.2.19 Pricing Actions Affecting Parking

Parking pricing strategies to discourage SOVs include:

- new or increased fees for solo drivers or long-term parkers;
- pricing preferences given to car and van-pools; and
- taxes on parking providers.

The effect of parking pricing on vehicle travel depends on many factors. Case studies suggest municipal parking pricing could be effective in reducing SOVs (Wilbur Smith Associates, 1992). However, pricing strategies could merely divert parking to different times and locations, or foster switching between HOV modes. While peak period surcharges and increases in long-term parking rates reduce commuter auto use, these measures also free parking for short-term parkers, facilitating shopping trips. Net VMT and energy reduction might be less than the proportion of commute trips reduced. When the City of Honolulu doubled long-term parking rates in 1981, the number of long-term parkers declined, but short-term parking increased. The total number of cars parked increased by six percent, and the number of available lunch hour spaces doubled (Di Renzo, 1981).

Pricing for municipal parking is set by City ordinance. Given the small proportion of downtown parking that is under municipal control, modifying pricing on municipal facilities could have very little effect on regional VMT.

The effect of this TCM on regional VMT and energy demand is probably minimal.

3.4.2.20 Employer Parking Pricing And Supply Actions

Employers could influence employee travel mode choice through parking strategies. Relatively small increases in parking prices in Honolulu, where prices are already high, could influence travel behavior. Reducing or ending parking subsidies could affect employee travel mode choices. The Alternatives to Employee Parking Subsidies (Wilbur Smith Associates, 1993a) evaluated three pricing options:

- *Charge parking:* Employees are charged at or near market rates.
- *Cash out:* The employer gives employees eligible for discounted parking a choice between the subsidized parking or the subsidy in cash.
- *Charge parking with travel allowance:* The employer charges at or near market rates for employee parking, but also offers a travel allowance on HOVs.

The study estimated possible effects of the three options on morning peak hour traffic to the Financial District, Kakaako, and Waikiki. The estimated reduction in weekday vehicle trips to the three areas varied from 3.6 to 9.9 percent under the different options. The highest reduction would occur in Waikiki under the Charge Parking option. The lowest reduction would occur in Kakaako under the Cash Out option.

Energy savings through parking pricing would depend on the amount of parking that would be displaced, and on the proportion of parkers diverted to new locations, compared to those diverted to HOVs.

The effect of this TCM on regional VMT and energy demand is probably minimal.

3.4.2.21 Employer-Based Rideshare Programs

Employer-based rideshare programs are strategies carried out by employers to reduce solo driving among employees. Programs include:

- encouragement of HOV use;
- guaranteed ride home;
- variable work hours;
- telecommuting; and
- encouragement of cycling and walking.

Successful employer-based programs usually include parking pricing strategies. Employers could carry out these strategies on their own, or in collaboration with an association of other employers, such as a Transportation Management Association (TMA).

Reductions in energy use under employer-based programs would depend on the effectiveness of the programs in reducing VMT. Employer-sponsored TSM measures affect employee commuter trips and not traffic bound for other sites. The size of the employer also appears to play a role in TSM program effectiveness since larger employers have more resources to devote to implementation, and larger numbers of employees facilitate implementation.

Some form of government regulation may be necessary for lasting implementation of employer based programs. Government could require that a certain level of an employer's commutation requirement be provided by non-SOV modes, as arranged and coordinated by the employer. The South Coast Air Quality Management District (SCAQMD) required employers of more than 100 people at a job site to implement a plan to encourage their employees to rideshare to work. The typical ridesharing target is 1.5 average vehicle ridership. This measure has been quite unpopular among employers.

The effect of this TCM on regional VMT and energy demand is probably minimal.

3.4.2.22 Variable Work Hours

Variable work hour programs manage travel demand by:

- shifting commuters away from the maximum periods; or
- reducing the number of work trips by extending the hours worked each day, thereby decreasing the number of days worked. Compressed work week schedules allow employees to work four days per week, ten hours per day.

The three principal forms of variable work hour programs are: staggered hours; compressed work weeks; and flextime.

Variable work hours relieve traffic congestion by shifting commuting out of the peak, thereby reducing travel time. Staggered hours and flex-time would also relieve congestion at parking access points. Variable work hours indirectly affects travel mode choice and non-work trips, making ride-sharing more difficult to implement. Compressed work weeks appear to reduce total VMT.

The evaluation of the 1988 Staggered Work Hours Demonstration Project in Honolulu (Guliano and Golob, 1989) indicated that spreading the peak travel demand period had a beneficial effect on traffic conditions. However, the effect was small and distributed unevenly. It was concluded that the potential benefits of staggered hours did not outweigh the costs of a mandatory program, and that future programs should therefore be voluntary.

Government could promote variable hour programs in the private sector and implement them among their own workers.

The effect of this TCM on regional VMT and energy demand is probably limited.

3.4.2.23 Telecommuting

Telecommuting reduces home-to-work trips by allowing employees to work at home or at telework centers in outlying residential districts. There could be computers, faxes and modems at the telework center. Telework centers may be run by single or multiple employers. Telecommuting could significantly reduce work trips. It affects the working environment and culture of an employer, however, and the degree to which telecommuting would gain widespread acceptance remains to be determined. Telecommuting is more easily encouraged in some industries than others. Telecommuting could affect off-peak and non-work trips.

Government could facilitate telecommuting programs by providing and encouraging telecommuting infrastructure. Government could demonstrate telecommuting for its own employees, as it is doing at the telework center at the Mililani High Technology Center, and develop guidelines for consideration by the private sector.

The effect of this TCM on regional VMT is not clear.

3.4.2.24 Transportation Management Associations (TMAs)

TMAs are groups of public and private parties that address local transportation problems. They typically consist of employers, developers, building owners, officials of transit districts and/or rideshare organizations. They attempt to build consensus for transportation solutions, and political and monetary support for action. They often sponsor transportation services such as:

- car-pool matching;

- shuttle buses to transit lines and/or shopping areas;
- sale of transit passes;
- guaranteed ride home programs;
- promotional events in support of transit, cycling and ridesharing; and
- information on TSM programs.

In 1991, there were about 110 TMAs operating or forming in the United States. Evaluations of TMAs are relatively rare, and it is difficult to quantify changes in travel behavior from TMA implementation. Reductions in energy use would depend on decreases in SOV use.

Government could encourage formation of TMAs. Most TMAs are initiated through informal and voluntary interactions between developers, local governments, employers and transit and rideshare agencies.

The LOTMA, Hawaii's first TMA, was formed as a voluntary non-profit organization in 1990. It contains representation of private landowners and public agencies, and focuses on transportation issues in the Ewa-Central region of Oahu. LOTMA is providing ridesharing and other services, and could provide more services with additional support, an option for state consideration. The state could also initiate other TMAs on Oahu and the neighbor islands.

The effect of this TCM on regional VMT and energy demand could be significant.

3.4.2.25 Trip Reduction Ordinances (TROs)

TROs require employers and/or developers to implement TSM programs. The ordinances typically require:

- an on-site transportation coordinator responsible for implementing TSM programs (e.g., ridesharing, transit pass distribution, variable work hours, parking management, and alternative mode information);
- a periodic survey of employee travel patterns to monitor program effectiveness and employee perspectives; and
- a periodic report to be filed with a public agency to demonstrate effective implementation of TSM strategies.

TROs often specify a goal that must be reached, usually a reduction among employees in the proportion of solo drivers or peak period auto trips.

In 1990 there were at least 23 communities nationwide with trip reduction ordinances, and about 12 others considering their adoption (Urban Land Institute, 1990). Effectiveness depends on many factors. TSM measures tend to be more successful at larger companies. Reduction in energy use would depend on the effectiveness of the programs in reducing VMT.

The Honolulu City Council's Committee on Transportation and Government Operations developed a draft TRO in 1992, but it was not enacted.

The effect of this TCM on regional VMT is not clear.

3.4.2.26 Actions By Educational Institutions

Schools are major contributors to travel demand and congestion on Oahu, particularly in the morning. The University, colleges and private schools generate most school-related vehicle trips. A 1986 OMPO study (Kaku Associates and Barbara Sunderland & Associates, 1986) estimated that school-related trips represent about 30 percent of the total trips to the primary urban center on Oahu, and that private school-related trips were more likely to be made by car than public high school trips.

Educational institutions could implement:

- school hour changes;
- an expanded school bus program; and
- program activities at branch locations.

A more recent study sponsored by OMPO (Wilbur Smith Associates, 1993c) recommended the following TSM measures for the University of Hawaii's Manoa Campus:

- establish a Transportation Task Force, set a program goal, and secure funding; and
- initiate TSM measures, such as ridesharing, flexible class hours, and school bus services.

The effectiveness of these TSM measures was not, however, presented in the study.

The effect of this TCM on the regional VMT and energy demand could be significant.

3.4.2.27 Pricing Or Other Control Of Automobile Use

Road pricing and control strategies include:

- *Road Pricing:* Road users would be charged for some trips. Pricing could vary by time of day, location and vehicle occupancy. Road pricing could be applied to expressways, principal arteries within a congested travel corridor, congested bridges or tunnels leading into central areas, and surface streets within congested zones. IVHS techniques could be employed to detect trips and generate periodic billings to vehicle operators.
- *VMT and/or Emission-Based Vehicle Fees:* Annual charges could increase with miles driven. The fee could replace other vehicle registration fees. It could be imposed at vehicle safety checks, or registration renewal.
- *Fuel Tax Increases:* Fuel tax increases have been used in the past to enhance revenues. Because such taxes are so general in scope and broad in their impact, their use as a TSM is highly controversial.
- *Tradable Travel Permits:* Travel permits for certain congested road facilities or zones at designated times could be allocated up to an allowance. Drivers would be allowed to buy and sell permits.

- *Car ownership controls:* Some have suggested the establishment of a requirement to trade in a used car for each purchase of a new car (Mattheson, 1994). Other possible restrictions could be placed on the number of vehicles per family or per household. These ownership controls would present many implementation issues.

Road pricing could potentially produce the most targeted traffic reductions because it could be made highly location and time specific. In areawide applications, road pricing could be significantly more effective than parking measures because road pricing would affect through trips, as well as trips originating or ending in the CBD. Through trips constitute a significant proportion of trips in most urban areas.

Road pricing is viewed by some as highly regressive because low income groups have legitimate travel needs to zones that would be priced, and often live furthest away. There are various mechanisms for exempting certain population groups or rebating revenues.

Case studies suggest that the effects of road pricing strategies would depend on the level of congestion, level of charges, travel characteristics and alternative travel opportunities. If implemented as a severe disincentive to SOVs, it could be highly effective in reducing vehicle trips and congestion.

Effects of road pricing on energy consumption would depend on how commuters shift between alternative travel routes, and modes and times of travel. "Downtown" areawide road pricing programs could produce ten percent or greater reductions in energy use associated with travel in the area (Wilbur Smith Associates, 1992). Regionwide road pricing programs have the potential to produce a 5 percent or more reduction in energy use (U.S. Environmental Protection Agency, 1990).

Automobile pricing strategies have not been used as TSM measures on Oahu. There was discussion of applying for a federal grant to initiate a pilot program, but there was no local consensus.

Requiring that a used car be traded in for each new car purchase, or establishing some other form of car ownership restriction, does not appear to have much political support at the present time.

The effect of this TCM on regional VMT could be significant, depending on details of implementation.

3.4.2.28 Land Use Patterns And Energy

Treatises have been written about the relationship between land use, energy and lifestyle (see for example Cervero, 1989; Cervero, 1993; Douglas, 1992). All agree that land use patterns profoundly affect transportation energy demand. Across the United States, low-density suburbanization has essentially been designed around a premise of inexpensive use of the automobile, one of the more energy-inefficient transportation modes. Many suburban communities developed when the nation was rather uncritically enraptured by SOVs. Of political interest, SOV disincentives would be particularly linked to lifestyle changes in these types of communities.

Land use patterns that create higher population and workplace densities, and multi-functional neighborhoods, are much more compatible with non-automobile modes of travel. In concept, higher densities and a greater mix of uses could create communities where residences were located closer to workplaces and services. This would decrease VMT and facilitate transit. The best opportunity to create communities amenable to energy-efficient transportation is before the land is developed, since redevelopment is more expensive, problematic and uncertain. Because the state still has extensive open areas that are planned for residential development, there is an opportunity to control this future development by adopting land use policies that encourage non-automobile transportation, and reduce the need to travel. Appropriate land use patterns, zoning, and building codes,[8] the most fundamental way to affect transportation energy demand over the long term, must be implemented over decades.

Table 3-4 summarizes some land use concepts currently being discussed that could reduce transportation energy demand. In general, the land use concepts on Table 3-5 reduce the need to travel, and help transit, car-pooling, walking and bicycling to become viable alternatives to SOVs. The fourth column shows just a few examples of these concepts as they have been or could be applied in Hawaii. Several of the examples highlight Hawaii redevelopment efforts, such as Kakaako.

Many concepts in Table 3-4 consist of mixing land uses, such as residential and workplace. Energy savings could materialize by enabling people to live closer to their workplace. This proximity could encourage walking, biking, and transit, and reduce VMT on those trips which could not be converted from SOVs. In suburban employment centers, higher proportions of workers walked or bicycled to work when on-site housing was available (Cervero, 1989). However, energy savings would not materialize if housing prices did not match the jobs provided nearby, since workers would then need to commute from affordable housing some distance away.

The Kakaako Community Development District is a governmental attempt to redevelop a deteriorating industrial-commercial area into a mixed-use residential-office-commercial-light industrial area where people could live, work, shop and recreate without leaving the area. Kakaako is also less than a mile away from downtown Honolulu, enabling Kakaako residents working downtown to have many transportation alternatives.

Another significant mixed use development on Oahu is Kapolei, a secondary urban center now being constructed in the Ewa district, approximately 20 miles from downtown. There is much local interest in whether this experiment actually achieves its potential to assist in attaining many state goals, beyond those pertaining to energy. Efforts to support Kapolei are evident:

- Government agencies have relocated workers to Kapolei, and more relocations are planned;
- Improvement to Barbers Point Harbor are occurring and planned;
- Road infrastructure improvements are occurring;
- Many of those involved in Kapolei construction have opened branch offices there; and

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[8] Building codes are included because they affect parking ratios and other design aspects with energy implications.

Table 3-4

Selected Innovative Land Use Planning Concepts with Potential for Transportation Energy Savings

Description	Consequences for Energy Savings	Potential for Hawaii	Source
Mixed residential and employment land uses	Energy savings could occur when people live and work within walking or biking distance	1) Kaka'ako Community Development District 2) Kapolei Secondary Urban Center 3) Resort provision of housing for employees	1 2
Shops and services within walking distance of residential areas	If half of 1/2 to 5 mile vehicle trips for shopping and personal business were reduced to below 1/2 mile, total vehicle trips might decline by 5%, and gasoline savings could be between 1-2%	1) Kaka'ako Community Development District 2) Kapolei Secondary Urban Center	1 3
Shops and services near employment centers, transit shops, and park-and-ride lots	If one in ten personal vehicle trips were made on foot as a result of this land use concept, energy consumption due to personal travel could decline by 3%	1) Kaka'ako Community Development District 2) Kapolei Secondary Urban Center	1 3
Locate housing units and increase their density near transit	Nationwide, in 1983, 10.3% of people living within 1/4 mile of transit used transit to get to work	1) Kaka'ako Community Development District 2) Kapolei Secondary Urban Center	1 3
Locate and increase employment near transit	Increase transit patronage	1) Kaka'ako Community Development District 2) Kapolei Secondary Urban Center	1 4
Design land uses with transit access in mind	Increase transit patronage	1) The Villages of La'i Opua 2) Kapolei Secondary Urban Center	1

Table 3-4

Selected Innovative Land Use Planning Concepts with Potential for Transportation Energy Savings (continued)

Description	Consequences for Energy Savings	Potential for Hawaii	Source
Diverse and compact housing	1) More economically accessible to transit and bus services 2) Shops and services could be provided within walking distance 3) Carpools and vanpools easier to implement	1) Kaka'ako Community Development District 2) Kapolei Secondary Urban Center	1 5
Grid street system	1) A grid system instead of a cul-de-sac, collector street system could reduce VMT within a neighborhood by 50-60% 2) For every 100 short trips diverted from a car to walking or bicycling, 5-26 gallons of gasoline could be saved	1) Kapolei Secondary Urban Center	1 6
Bike lanes and paths	At least half of all trips are 5 miles or less in length. If 5% could be diverted to bicycles, a 1% reduction in gasoline consumption could be the result	1) Kapolei Secondary Urban Center	1
Bike parking and facilities	Same as above	1) Kapolei Secondary Urban Center	1

Table 3-4

Selected Innovative Land Use Planning Concepts with Potential for Transportation Energy Savings (continued)

Description	Consequences for Energy Savings	Potential for Hawaii	Source
Pedestrian facilities	If 20-50% of vehicle trips under 1/2 mile could be diverted to walking, overall vehicle trips would be reduced by 2-5%	1) Kapolei Secondary Urban Center	1
Creating pedestrian and transit oriented communities	Studies indicate that residents in more compact, mixed use developments use half the gasoline for transportation than comparably sized suburban lower-density development	1) Kapolei Secondary Urban Center	1 7

Sources:
1) California Energy Commission, May 1992.
2) Cervero, 1989.
3) U.S. Department of Transportation, November 1986.
4) U.S. Department of Transportation, August 1991.
5) Holtzclaw, April 1990.
6) Kulash, March 1990.
7) Real Estate Research Corporation, 1974.

- Other Kapolei projects to be started include:

  a) Kapolei Regional Park;
  b) Bank of Hawaii building;
  c) Consolidated Theaters, 16 Screens;
  d) Zippy's Restaurant;
  e) Kapolei Power Center;
  f) Seagull School's child care facility;
  g) Kapolei Police Station;
  h) First Hawaiian Bank building; and
  i) State Public Library.

Fulfillment of Kapolei's promise would depend on its success in developing employment centers, and the actual ability of workers in Kapolei to live in Kapolei.

Opportunity for energy savings also exists in the urban design of this community. However, it appears that provisions have not been made for such measures as higher density housing around transit stops, station placement near homes, and bicycle and pedestrian facilities.

Other major land developments, such as Ewa Marina on Oahu and the Villages of La'i 'Opua on the Island of Hawaii, present an opportunity like Kapolei's to develop energy saving communities, but they also face important urban design issues to be resolved during implementation.

Some of Hawaii's resorts could provide housing for their employees' families close to the workplace. Such company-sponsored residential areas would reduce gasoline consumption by reducing VMT, create an opportunity for efficient HOV shuttle services, and help alleviate the scarcity of affordable housing in Hawaii.

Locating shops and services within walking and bicycling distance of residences is another form of land use mixing that could result in significant transportation energy savings. As an example, higher residential densities near malls could be encouraged. Nationally, 38 percent of all vehicle trips and 29 percent of total VMT are for shopping and personal business, with 60 percent of these trips being between one-half and 5 miles (U.S. Department of Transportation, 1992). If half of these trips could be shortened to under one-half mile, and half of these trips made by walking instead of automobile, reductions in VMT and gasoline usage could be from 1 - 2 percent (U.S. Department of Transportation, 1992). While these figures are based on national averages, this land use combination could save energy in Hawaii.

Another land use combination listed in Table 3-4 involves locating shops and services near work sites, transit stops, and park-and-ride lots. If one in ten of all vehicle trips made for shopping and personal business were made by foot or bicycle, from workplace origins, or while commuting, energy consumption for personal travel could be reduced by 3 percent (U.S. Department of Transportation, 1992). For example, park-and-rides, kiss-and-rides, and transit centers could be located in or adjacent to shopping centers. (For example, Ala Moana Center is both a shopping center and a transit center). Locating restaurants, banks, services, daycare centers, and convenience stores near employment centers could encourage more walking trips, make it easier to combine trip purposes, facilitate ridesharing (since one of the barriers to car-pools is that their home to work routing does not allow for running errands), and encourage transit. Downtown Honolulu succeeds in providing many shops and services within walking distance of workplaces and transit centers, like the Hotel Street Bus Mall.

Locating shops, services and park-and-rides near transit stops could encourage transit use by enhancing convenience. Certain land use practices listed on Table 3-4 could also facilitate the effectiveness of transit. For example:

- Increasing the residential density within one-quarter or one-half mile of express transit stops, which could boost transit ridership at the expense of SOVs. In one study, approximately 10 percent of all people living with 1/4-mile of a station used transit to get to work (U.S. Department of Transportation, 1992).
- Locating employment centers near transit stations.
- Encouraging building designs that facilitate transit, such as providing inviting pedestrian access to the building from a transit stop; eliminating barriers to pedestrian flow around transit stops such as walls, roads and large parking lots; designing transit stops within building complexes; and placing structures closer to transit stops and routes.

The term "joint-development" is used to describe the co-development of commercial and residential uses with a transit station. Commercial/transit joint developments are now quite common. Examples include the World Trade Center (WTC) in New York City. This is an office building where 50,000 people are employed which is served by no less than nine rail transit routes. Battery Park City, a residential development of 7,000 people, is immediately adjacent to the WTC. This joint development complex succeeds in replacing millions of VMT by pedestrian travel.

Private developers could pay for joint development rights,[9] and with appropriate financial arrangements, revenues from joint-development opportunities could be used to support the transit system. Honolulu's rail transit proposal included joint development plans at several of the stations.

Developing higher density residential communities would also result in transportation energy savings. Compact communities are more efficiently served by transit services, have more neighborhood shops and services within walking and bicycling distance of homes, and facilitate the formation of car-pools and van-pools. A study of five San Francisco Bay Area neighborhoods showed that as residential density increased, annual VMT (and therefore fuel consumption per capita) decreased (Holtzclaw, 1990). A 1974 study (Real Estate Research Corporation, 1974) compared communities of approximately 10,000 housing units and found that those living in more compact, mixed-use developments used half the gasoline for transportation of those living in less dense suburban developments.

By providing a network of fully connected streets, such as a grid system, shorter, more direct routes are facilitated. For example, in comparison to a pattern of cul-de-sacs with collector streets, a grid system could reduce VMT generated within a neighborhood by 50 to 60 percent, thereby reducing energy consumption (Kulash et. al, 1990). Terrain features could make such a road network impractical in some areas of the state, however.

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[9] Joint development rights can be quite valuable. Tenants and owners will pay a premium to reside or work near a well-designed transit station with a good mix of shops and services. Retail establishments are attracted by the volumes of potential customers that would pass by their door.

In spite of the available land use patterns, it is instructive to examine the experience of Portland, Oregon. Portland's Land Conservation and Development Commission set a goal of zero VMT per capita growth for 10 years (VMT growth would equal population growth), a 10 percent decrease in annual per capita VMT within 20 years, and within 30 years, a 20 percent decrease in annual per capita VMT. Although these policies have been in place for 10 years, VMT growth per capita continued, and was at four percent per annum between 1980 and 1990 (meaning that VMT grew substantially faster than the population), higher than the decade before the policies were put into place.

The effect of land use on regional VMT and transport energy demand is significant.

3.4.3 ENERGY-SAVINGS EFFECTIVENESS OF THE IDENTIFIED TCMS

Many of the TCMs (though not all) attempt to influence the choice of a transportation mode. Table 3-5 compares average energy intensities for different travel modes on a national basis, and because information was readily available, parameters for Honolulu's TheBus are also shown. Figure 3-1 graphically compares average energy intensities for the different travel modes.

From Table 3-5, it is apparent that, from an energy perspective, the state should be pursuing inducements and disincentives to shift travelers away from SOVs and onto TheBus, except that capacity is limited. It may be noted that TheBus is 2.2 times more energy-efficient (BTU per passenger-mile) than the average U.S. transit bus system, but at the cost of overcrowding on certain routes at peak times. Service enhancements would be needed for the capacity of the system to handle appreciable numbers of those who could be diverted from their SOVs.

As discussed above in Section 3.1, determining the effectiveness of TCMs is quite difficult. A California attempt is shown in Table 3-6, but these results are based on specific studies done for Los Angeles and San Francisco, and are not applicable to Hawaii. However, within the transportation planning field, an aggressive package of TCMs is typically estimated to have at most a 10 percent impact on regional VMT. Improvements to OMPO's traffic model, new travel demand surveys, and other improvements in the basic transportation planning tools on Oahu are occurring, however, and some results based on new traffic modeling are presented in section 3.5. It is notable that a recent California analysis of ground sector energy demand (California Energy Commission, 1994) also stressed the improvement of transportation planning tools, and did not express confidence in existing numerical estimates of TCM effectiveness.

Table 3-5

Passenger Travel and Energy Use in the United States, 1990

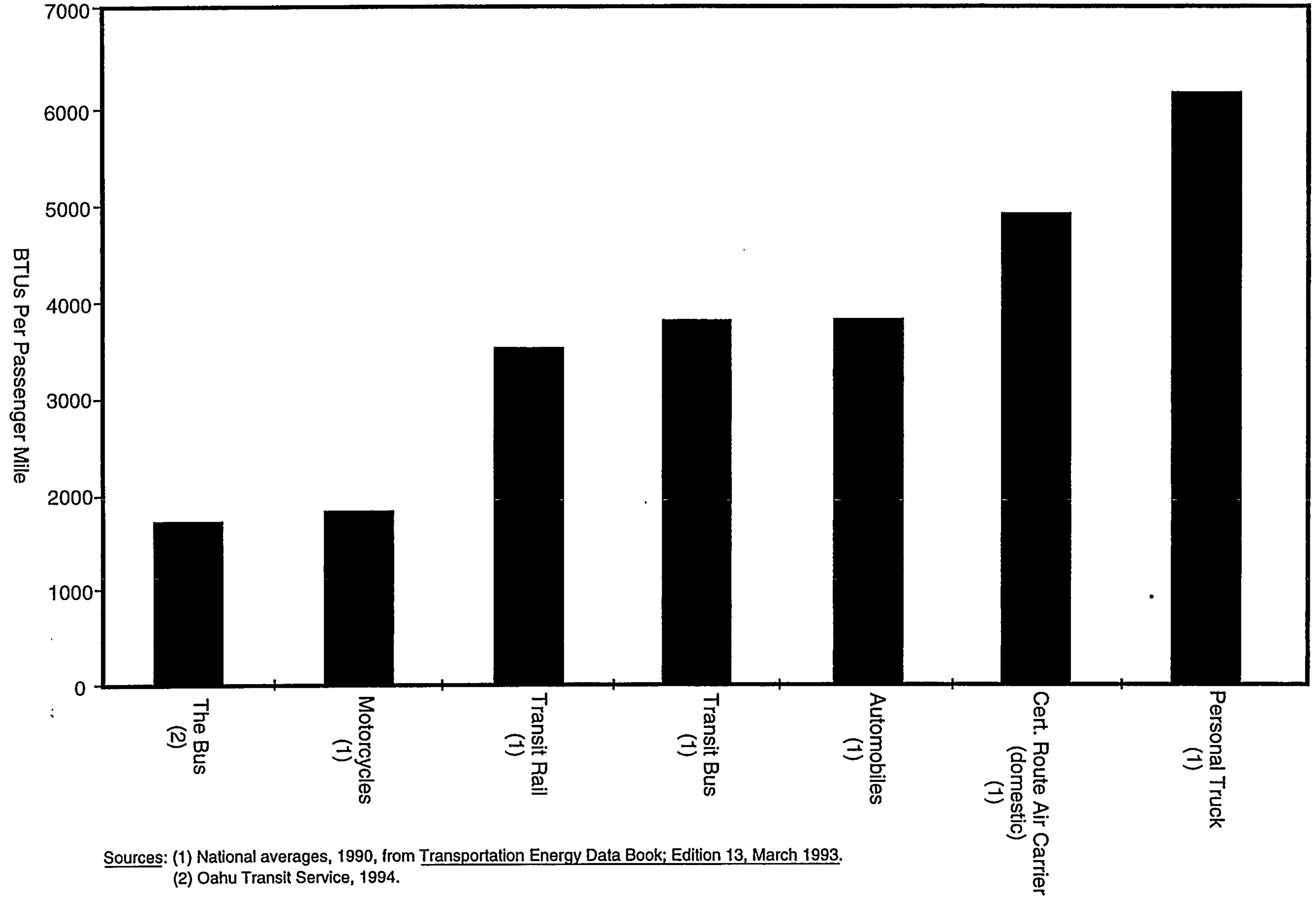
Travel Mode	Number of Vehicles (Thousands)	Vehicle Miles (Millions)	Passenger Miles (Millions)	Load Factor (Persons/Vehicle)	Energy Intensities (BTU Per Vehicle-Mile)	Energy Intensities (BTU Per Passenger-Mile)	Energy Use (Trillion BTU)
Automobiles	143,549.6	1,515,370	2,424,592	1.6	5,983	3,739	9,0663
Personal Trucks	27,161.9	296,151	444,227	1.5	9,063	6,042	2,684.0
Motorcycles	4,259.5	9,572	13,401	1.4	2,497	1,783	23.0
Buses	588.7	6,944	18,327	17.0	23,334	1,376	23.9
Transit	59.8	2,153	21,127	9.8	36,647	3,735	162.8
Intercity	20.6	991	23,000	23.2	220,010	944	78.9
School	508.3	3,800	74,200	19.5	419,677	838	21.7
TheBus (Honolulu)	0.472	17.5	335	22.0	31,427	1,666	62.2
Air	[1]	8,161	358,763	44.0	220,010	5,605	0.69
Certified Route (domestic)	[1]	3,964	345,763	87.2	419,677	4,811	1,795.5
General Aviation	212.2	4,197[2]	13,000	3.1	31,427	10,146	1,663.6
Recreational Boats	10,134.0						246.7
Rail	17.9	1,075	25,310	23.5[3]	73,581	3,125	79.1
Intercity	2.1[4]	301[5]	6,057[6]	20.1[3]	52,492	2,609	15.8
Transit	11.3	561	12,046	21.5[3]	74,153[7]	3,453	41.6
Commuter	4.5	213	7,207	33.8[3]	101,878	3,011	21.7

Source: Transportation Energy Data Book: Edition 13, March 1993 and Oahu Transit Service, 1994.

Notes:
1) Data are not available.
2) Nautical miles.
3) Based on passenger train car-miles.
4) Sum of passenger train cars and locomotive units.
5) Passenger train car-miles.
6) Revenue passenger miles.
7) Large system-to-system variations exist within this category.

Figure 3-1

Passenger-Mile Energy Intensities by Travel Mode



<u>Sources</u>: (1) National averages, 1990, from <u>Transportation Energy Data Book; Edition 13, March 1993</u>.
(2) Oahu Transit Service, 1994.

Table 3-6

Estimated Energy Effects of Selected TCMs in San Francisco and Los Angeles

Policy Type	Effect on Fuel Consumption at Full Implementation
Rail Transit System Expansion	800-1000 fewer gallons per day per mile of fixed rail
Rail Transit Access Service	0.2-0.4 percent reduction in fuel use from extensive subsidy of: 1) station-area on-call services 2) employer shuttles 3) activity center shuttles
Bus Transit Headway Improvements	0.2-0.6 percent reduction in fuel use for a doubling of existing bus frequencies (subject to a threshold average load factor)
Fuel Price	20-25 percent reduction in fuel use for the first $1.00 (1990$) increase in fuel price; about 10-15 percent reduction for the second $1.00 increase
Employee Parking Price	2-3 percent reduction from a $3.00 per day employee parking floor
Congestion Pricing	5-8 percent reduction in fuel use from elimination of all recurring delay
Pedestrian-Oriented Development (POD)	0.04-0.08 percent reduction in total regional fuel use for each 1 percent of new residential development in PODs
Increased Density Near Transit	0.02-0.1 percent reduction in total regional fuel use for each 1 percent of new residential development in higher-density conditions

Source: California Energy Commission, February 1994.

3.5 CONCLUSIONS

This section has presented several strategies for reducing energy demand in the state's transportation sector. While it is of interest to note energy-saving trends in the air and marine sectors, there is little opportunity for state or local governments in Hawaii to effect change in those sectors. Consequently, the state should focus its transportation energy-saving efforts on the ground sector.

The conservation option most powerfully and most easily quantified is improving vehicle fuel efficiency. Regardless of whether VMT could be reduced by other means, substantial amounts of energy would be saved with vehicle fuel efficiency improvements. Implementing vehicle efficiency improvements is discussed in Chapter 11.

It is quite difficult to determine the energy effectiveness of the many TCMs that have been presented in this section, either individually or working in synergistic combinations. Those measures that show the greatest energy-saving potential in the short- and mid-term operate by reducing total regional VMT through travel mode shifts away from SOVs, or by decreasing the need for travel. Different strategies work best on different sectors of the travel market. For example, home to work trips are perhaps best addressed by measures that encourage non-automobile travel models (e.g. transit), and higher utilization rates of automobiles (e.g. rideshare, HOV facilities). Shopping and errand trips are perhaps best addressed through encouragement of non-automobile modes (e.g. transit, walking) and appropriate land use patterns. Home to school trips could be addressed by other options (e.g. HOVs, educational institution actions). Therefore, a complete package to reduce VMT must take into account various trip purposes, the many implementation issues associated with each measure, and the synergies between TCMs. It is notable, however, that transit has a role in almost every travel market.

In addition, if measures are taken to reduce SOVs, alternatives with sufficient capacity and service must be available to satisfy the demand. Therefore, TCM measures must be implemented with a systems perspective.

Because of the update of the Oahu Regional Transportation Plan presently being conducted by OMPO, it is possible to estimate the energy savings associated with certain combinations of TCMs. Estimates of future regional VMT and also data suitable for the method of Shrank, et. al. (1993), which estimates energy waste associated with congestion, have been produced. This analysis indicates that by the year 2020, as much as an 18 percent energy savings could result from an aggressive suite of TCMs, including road pricing. Therefore, aggressive TCMs could substantially affect energy demand.

Improved transit service in association with some roadway improvements could yield a savings of around eight percent, and a rail/bus or electric bus system could displace a substantial amount of petroleum if non-petroleum fuels were utilized to generate the electric power.

Regional VMT has been identified as the key parameter for assessing a transportation project's impact on energy demand. It appears from this analysis that the following offer the most opportunity for decreasing regional VMT and energy demand:

- Public transit expansion;
- Transportation management associations;
- Actions by educational institutions;
- Land use patterns;
- HOV facilities; and
- Automobile use limitations.

Therefore, from an energy perspective, these TCMs should be encouraged. A discussion of whether it is sufficient to merely enhance the attractiveness of HOVs, without also providing disincentives for SOVs, is deferred to Chapter 11.

In conclusion, fleet efficiency improvements, and particular TCMs, including appropriate land use patterns, should all be part of a balanced approach to energy savings. DBEDT should continue to work with SDOT, OMPO and the counties to evaluate the energy impacts of proposed transportation improvements. Also, since fuel prices have an effect on trip generation and/or mode choice, further analysis on the possible impact of fuel price increases on travel behavior and energy demand would be of interest.

CHAPTER 4

AN INTRODUCTION TO ALTERNATIVE TRANSPORTATION FUELS

4.1 INTRODUCTION

As discussed in Chapters 2 and 3, even with energy conservation transportation energy demand is expected to increase.[1] However, this demand need not be satisfied with petroleum. Alternative fuels[2] have the potential to satisfy some of this energy demand, and appear to offer some advantages over petroleum including:

- increased security of supply for alternative fuels made from local resources;
- lower air emissions; and
- beneficial effects on the local economy by retaining more energy dollars in Hawaii and creating jobs rather than exporting these funds to the countries that control the oil supply.

Because of their potential, alternative fuels merit a more detailed evaluation. This chapter introduces the alternative fuels that have been considered in this project,[3] describes past governmental efforts to support alternative fuels, and estimates the potential for substituting petroleum with alternative fuels.

4.2 ALTERNATIVE TRANSPORTATION FUELS

This study addresses the following alternative fuels:

- alcohols: methanol and ethanol;
- natural gas and synthetic natural gas;
- propane (LPG);
- electricity;
- biodiesels; and

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[1] In the long term, increases in corporate average fuel economy (CAFE) standards could produce a decrease in demand compared to levels of the 1990's, but this is speculative.

[2] As used in this report, "alternative fuel" refers to any non-petroleum source of power appropriate for motor vehicle operation. This includes liquids and gaseous fuels as well as electricity. Consistent with the Energy Policy Act of 1992, propane is considered as an alternative fuel in this report as well. An "alternative fuel vehicle," as used here, refers to any vehicle specifically designed to run largely on an alternative fuel. More specific definitions can be found in the Energy Policy Act of 1992.

[3] The selection of which particular alternative fuels best satisfy Hawaii's energy goals and circumstances is deferred to Chapter 5.

- hydrogen.

Tables 4-1 and 4-2 summarize some key characteristics of the alternative fuels, and Tables 4-3, 4-4, and 4-5 list some alternative fuel vehicles (AFVs) which were built or were in production in mid-1993. Offerings of AFVs change quickly, so this information is provided only to give an example of AFV availability.

4.2.1 METHANOL

4.2.1.1 Introduction

Methanol, CH_3OH, is a liquid at room temperature. Since methanol was formerly produced from wood, it was commonly referred to as "wood alcohol." Most methanol is now produced from natural gas (methane), although it can also be produced from biomass or by gasifying coal. At present, natural gas-based methanol is cheapest.

Total world production of methanol is currently about five billion gallons per year. This amount could power approximately five million automobiles. However, most methanol is used as a feedstock for plastics, copier fluid, windshield wiper fluid, antifreeze, model airplane fuel, and octane enhancer.

Methanol is an excellent motor vehicle fuel and has been used for many years in selected applications such as racing.[4] Its high octane value (over 100) permits its use in high compression, high output engines.

As a transportation fuel, methanol is used in the following forms:

- M100 (100 percent methanol);
- M85 (85 percent methanol, 15 percent gasoline);
- Methyl Tertiary Butyl Ether (MTBE), an oxygenate which can be blended in small amounts with gasoline and used in conventional vehicles to reduce emissions and enhance octane; and
- small amounts of pure methanol as an oxygenate in gasoline (typically five percent methanol).

Manufacturers have produced automobile, truck and bus engines that use methanol. M85 is commonly used in spark ignition automobile engines while M100 is used in compression ignition heavy-duty engines.

The Pacific International Center for High Technology Research and the Hawaii National Energy Institute are developing a demonstration-scale biomass gasifier on Maui to produce a fuel gas mixture from biomass, ultimately resulting in the production of methanol. A project funded primarily by the U.S. Department of Energy National Renewable Energy Laboratory and the State of Hawaii seeks to produce methanol from indigenous biomass.

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[4] Its high heat of vaporization provides air cooling that results in a "turbocharger" effect.

Table 4-1
Properties of Transportation Fuels

Property	Gasoline	No. 2 Diesel Fuel	Methanol	Ethanol	MTBE	Propane	CNG (Methane)	Hydrogen
	Mixture of Hydrocarbons							
Chemical Formula	C_4 to C_{12}	C_3 to C_{25}	CH_3OH	C_2H_5OH	$(CH_3)COCH_3$	C_3H_8	CH_4	H_2
Density, lb/gal @ 60°F	6.0-6.5(b)	6.7-7.4(d)	6.63(b)	6.61(b)	6.19(m)	4.22	1.07(r)	--
Boiling temperture, °F	80-437(b)	370-650(d)	149(c)	172(c)	131(c)	-44	-259	-4,230(u)
Reid vapor pressure, psi	8-15(k)	0.2	4.6(o)	2.3(o)	7.8(o)	208	2,400	--
Octane no.								
Research octane no. (1)	90-100(u)	--	107	108	116(t)	112	--	130+
Motor octane no. (1)	81-90(s)	--	92	92	101(t)	97	--	--
(R+M)/2 (1)	86-94(s)	N/A	100	100	108(t)	104	120+	--
Blending octane (w)	--	--	115 (7)	111 (8)	110 (9)	--	--	--
Latent heat of vaporization								
Btu/gal @ 60°F	900 (approx.)(b)	700 (approx.)(b)	3340(b)	2378(b)	863(5)	775	--	--
Btu/lb @ 60°F	150 (approx.)(b)	100 (approx.)	506(b)	396(b)	138(5)	193.1	219	192.1(v)
Btu/lb air for stoichiometric mixture @ 60°F	10 (approx.)(b)	8 (approx.)	78.4(b)	44(b)	11.8	--	--	--
Heating value (2)								
Lower (liquid fuel-water vapor) Btu/lb	18,000-19,000	18,000-19,000	8,570(b)	11,500(q)	15,100(h)	19,800	21,300	51,532(v)
Lower (liquid fuel-water vapor) Btu/gal @ 60°F	115,000	128,400	56,800(3)	76,000(3)	93,500(4)	84,500	19,800(6)	--

Adapted from U.S.DOE, Energy Information Administration, Alternatives to Traditional Transportation Fuels: An Overview.

Notes:

(1) Octane values are for pure components. Laboratory engine Research and Motor octane rating procedures are not suitable for use with neat oxygenates. Octane values obtained by these methods are not useful in determining knock-limited compression ratios for vehicles operating on neat oxygenates and do not represent octane performance of oxygenates when blended with hydrocarbons. Similar problems exist for cetane rating procedures.

(2) Since no vehicles in use, or currently being developed for future use, have powerplants capable of condensing the moisture of combustion, the lower heating value should be used for practical comparisons between fuels.

(3) Calculated.

(4) Pour Point, ASTM D 97 from Reference (c).

(5) Based on Cetane.

(6) For compressed gas at 2,400 psi.

(7) At 5% in gasoline

(8) At 10% in gasoline

(10) At 15% in gasoline

Sources:

(a) The basis of this table and associated reference was taken from : American Petroleum Institute, *Alcohols and Ethers*, Publication No. 4261, 2nd ed. (Washington, DC, July 1988), Table B-1.

(b) 'Alcohols: A Technical Assessment of Their Application as Motor Fuels,' API Publication No. 4261, July 1976.

(c) *Handbook of Chemistry and Physics*, 62nd Edition, 1981, The Chemical Rubber Company Press, Inc.

(d) 'Diesel Fuel Oils, 1987', Petroleum Product Surveys, National Institute for Petroleum and Energy Research, October 1987.

Table 4-1
Properties of Transportation Fuels
(Continued)

[e] ARCO Chemical Company, 1987.
[f] "MTBE, Evaluation as a High Octane Blending Component for Unleaded Gasoline," Johnson, R.T., Taniguchi, B.Y., Symposium on Octane in the 1980's, American Chemical Society, Miami Beach Meeting, Sept. 10-15, 1979.
[g] "Status of Alcohol Fuels Utilization Technology for Highway Transportation: A 1981 Perspective," Vol. 1, Spark-Ignition Engine, May 1982, DOE/CE-56051-7.
[h] American Petroleum Institute Research Project 44, NBS C-461.
[i] Lang's Handbook of Chemistry, 13th Edition, McGraw-Hill Book Company, New York, 1985.
[j] "Data Compilation Tables of Properties of Pure Compounds," Design Institute for Physical Property Data, American Institute of Chemical Engineers, New York, 1984.
[k] Petroleum Product Surveys, Motor Gasoline, Summer 1986, Winter 1986/1987, National Institute for Petroleum and Energy Research.
[l] Based on isoctane.
[m] API Monograph Series, Publication 723, "Tert-Butyl Methyl Ether," 1984.
[n] BP America, Sohio Oil Broadway Laboratory.
[o] API Technical Data Book - Petroleum Refining, Volume I, Chapter I. Revised Chapter 1 to First, Second, Third and Fourth Editions, 1988.
[p] "Automotive Gasolines," SAE Recommended Practice, J312 May 1986, 1988 SAE Handbook, Volume 3.
[q] "Internal Combustion Engines and Air Pollution," Obert, E.F., 3rd Edition, Intext Educational Publishers, 1973.
[r] Value at 80 degrees F with respect to the water at 60 degrees F (Mueller & Associates).
[s] National Institute for Petroleum and Energy Research, Petroleum Product Surveys, *Motor Gasolines, Summer 1992*, NIPER-178 PPS 93/1 (Bartlesville, OK, January 1993), Table 1.
[t] P. Dorn, A.M. Mourao, and S. Herbstman, "The Properties and Performance of Modern Automotive Fuels," Society of Automotive Engineers (SAE), Publication No. 861178 (Warrendale, PA, 1986), p. 53.
[u] C. Borusbay and T. Nejat Veziroglu, "Hydrogen as a Fuel for Spark Ignition Engines," *Alternative Energy Sources VIII, Volume 2, Research and Development* (New York: Hemisphere Publishing Corporation, 1989), pp. 559-560.
[v] *Technical Data Book*, Prepared by Gulf Research and Development Company, Pittsburgh, PA, 1962.
[w] *Properties of Alcohol Transportation Fuels*, Prepared for U.S. Department of Energy by Meridian Corporation, 1991.

Table 4-2

General Comparison of Alternative Fuels

Fuel	Advantages	Disadvantages
Methanol	1. Could be produced locally from Hawaii materials ("feedstocks"). 2. Used for years in racing engines. 3. California's AFV program has focused on methanol; extensive data available. 4. Flexibly-fueled vehicles capable of operating on M85 (85% methanol, 15% gasoline), 100% gasoline, or any combination, are available from major auto manufacturers for the same price as gasoline vehicles. 5. Bus & truck engines which use 100% methanol are available from major manufacturers. 6. High octane. 7. Burns cleaner than gasoline.	1. Not yet locally available as a fuel. 2. Price of methanol on a per-mile basis, in Hawaii, would currently be more than for gasoline. New methods of fuel production are expected to eventually make the fuel price competitive with gasoline and diesel. 3. It takes 1.7 - 1.9 gallons of methanol to go as far as 1 gallon of gasoline. 4. Imported methanol would predominantly be made from non-renewable natural gas.
Ethanol	1. Could be produced locally from Hawaii materials ("feedstocks"). 2. Can be blended (up to 10%) with gasoline and used in existing cars. Blending gasoline with 10% ethanol raises fuel octane about 3 points. 3. Flexibly-fueled vehicles capable of operating on E85 (85% ethanol, 15% gasoline), 100% gasoline, or any combination, are available from major auto manufacturers for the same price as gasoline powered vehicles. 4. Bus & truck engines which use 100% ethanol are available from major manufacturers. 5. Burns cleaner than gasoline. 6. High octane. 7. Non-toxic. 8. Made from renewable sources.	1. Not yet locally available as a fuel. 2. In order for ethanol to be blended (10%) in gasoline, the base fuel may need to be adjusted and blending equipment may need to be installed. 3. Current market price of ethanol is more than for gasoline and diesel. New methods of fuel production from biomass are expected to eventually make the fuel price competitive with gasoline and diesel. 4. It takes 1.3 - 1.5 gallons of ethanol to go as far as 1 gallon of gasoline.
Propane	1. Has been used in Hawaii as a transportation fuel for over 25 years; infrastructure in place. 2. Conversions of existing vehicles and technical support are available locally. 3. Light-duty trucks warranted for use with propane are available from major manufacturers. 4. Reduced carbon monoxide emissions. 5. High octane.	1. Fossil fuel based (refinery byproduct or natural gas reserves); non-renewable. 2. Must be stored under pressure.
Natural Gas	1. Could be produced locally from Hawaii materials ("feedstocks"). 2. Bus and truck engines capable of operating on natural gas are available from major engine manufacturers. 3. Burns cleaner than gasoline.	1. Fuel not locally available, and not economic to import to Hawaii. 2. Compressed natural gas (CNG) has to be stored at very high pressure (2500 psi). 3. Refueling equipment is expensive; refueling may take several hours. 4. Liquefied natural gas (LNG) must be stored at very low temperatures, requiring special, insulated tanks (-260°F). 5. It takes 3.6 gallons of CNG or 1.6 gallons of LNG to go as far as 1 gallon of gasoline.
Hydrogen	1. Extremely low emissions. 2. Renewable; can be made from many different materials, including water.	1. In the research and development stage. 2. Not yet commercially available.

Table 4-2 (continued)

Fuel	Advantages	Disadvantages
Electricity	1. Electricity could be produced locally from Hawaii materials including biomass, solar or wind power. 2. A major part of the necessary infrastructure (electrical distribution system) is already in place. 3. Fuel cost is less per mile than gasoline or diesel. 4. Electric power plants and electric vehicles are more energy-efficient than internal-combustion engines. 5. No tailpipe emissions, and reduced overall emissions. 6. Charging at night (off-peak) would provide operational benefits to electric utilities which currently have a nighttime energy demand below their optimum minimum.	1. Currently available vehicles have range of less than 200 miles between charges. 2. Standards and infrastructure for battery charging and vehicle servicing are still under development. 3. Electric vehicles cost more than their gasoline counterparts; although higher volumes of production would reduce this difference. 4. Current electric-only vehicle technology is not appropriate for long distance heavy-duty truck and bus applications. 5. Disincentives to daytime charging from the grid must be put into place to avoid increasing demand for electricity during peak demand periods.
Biodiesel	1. Could be produced locally from Hawaii materials ("feedstocks") including waste cooking oils. 2. May be blended with regular diesel and used in existing diesel engines with minimal modification. 3. Biodiesel blends reduce emissions of particulates and smoke. 4. One gallon of biodiesel will go as far as one gallon of regular diesel. 5. Made from renewable sources.	1. Still undergoing testing and certification. 2. Not a gasoline replacement. For use in diesel engines only. 3. Retail price of biodiesel is much more than for regular diesel.

Source: State of Hawaii, DBEDT, 1993.

Note: For more information refer to the Hawaii Energy Strategy Project 2 (State of Hawaii, DBEDT, 1993).

Table 4-3

Light- and Medium-Duty Internal Combustion Engine Alternative Fuel Vehicles

(listed vehicles have been built or were in production as of mid-1993)

Fuel	Vehicle Type	Manufacturer	Model[1]
Methanol[2]	Minicompacts	Nissan	NX1600
	Subcompacts	Toyota	Corolla
	Compacts	Ford	Escort
		Mazda	Protege
		Nissan	Stanza
		Volkswagen	Jetta('92)
	Mid-Size Sedans	Chrysler	Concorde
			Dodge Intrepid
			Dodge Spirit ('92, '93)
			Eagle Vision
			Plymouth Acclaim ('92, '93)
		Ford	Taurus ('91, '93)
		General Motors	Chevrolet Corsica
			Chevrolet Lumina ('91, '92, '93)
		Mitsubishi	Galant
		Volvo	940
	Luxury Sedans	Mercedes	300S
	Station Wagons	Ford	Crown Victoria ('89, '90)
	Vans	Chrysler	Plymouth Voyager
		Ford	Econoline ('92)
Natural Gas	Passenger Cars	Chevrolet	Caprice (conversion-ready)
	Station Wagons	Chrysler	Dodge B-Series
		Ford	Crown Victorias
	Vans	Chrysler	Dodge B-Series
		Ford	Forthcoming
	Pick-Up Trucks	Chevrolet	C1500-Series
		Chevrolet	C2500-Series
		Ford	Ranger
		GMC	Sierra 1/2 ton
		GMC	Sierra 3/4 ton
	Medium Duty Trucks	Ford	F-Series
Propane	Station Wagons	Chevrolet	Suburban 5.7L
	Vans	Chevrolet	5.7L engine
		Ford	Econoline E150/E250
	Pick-up Trucks	Chevrolet	3/4 and 1 ton
	Medium Duty Trucks	Chevrolet	366/427 CID engines
		GMC	366/427 CID engines
		Ford	429 CID engine

Notes:

1) Model Year information is shown for vehicles which have been produced in volumes of 100 or more.

2) Vehicles are marketed as methanol vehicles. Vehicles designed for methanol may operate on ethanol with minor adjustments. GM, Ford and Volkswagen have completed necessary testing for calibration.

Table 4-4

Electric Vehicles
(listed vehicles were under development, have been built, or were in production as of Mid-1993[1,2])

Class of Manufacturer	Vehicle Type	Manufacturer	Model
These Original Equipment Manufacturer (OEM) vehicles are under development and some are expected to be available for sale to the public around 1998	Passenger Cars	BMW	E1 (Europe), E2 (U.S.)
		Chrysler EPIC	EPIC
		Fiat	Panda Elletra, Cinquescent Ellectra
		Ford Commuter Car	No model yet identified
		General Motors	Impact
		Mazda	Miata
		Nissan	Cedric, FEV
		Peugeot	Model 106 size
		Renault	Zoom, Master, Express, Electro-Clio
		Volkswagen	Chico, Golf/Jetta
		Volvo	Gas turbine hybrid concept car
	Vans	Chrysler	TEVan
		Ford	Ecostar
		GM	Conceptor G-Van
		Peugeot	small van
		Renault	Express Van
Small EV Producers	Passenger Cars	AC Propulsion	ELX (converted Honda CRX)
		California Electric Cars	2-person sports car
		Solar Car Corp.	Festiva Electric
		Solectria	Converts new & used
		U.S. Electricar	Force (converts new 2 & 4 seaters)
	Pick-Up Trucks	Solar Car Corp.	Converts mainly Ford
	Shuttle Buses	Bus Manufacturing USA	Forthcoming
		Clean Air Transit	22-passenger
		Nordskog Manufacturing	22- and 26-passenger
		Eldorado	22-, 26-, and 31-passenger
	Three-Wheelers or Other Small Specialty Vehicles	Cushman	500 lb capacity
		Nordskog	Various
		Sebring Auto-Cycle	Zzipper
		Taylor-Dunn	Various
		Suntera	

Notes:

1) Prototype electric versions of models other than those listed here may have been developed at one time. (e.g. Mazda has developed over 70 prototype EVs since the 1970s.)
2) This is not a complete list. Virtually all major manufacturers have EV programs and a large number of small manufacturers or converters exist of which only a few are represented here. In addition, many component manufacturers exist and are not listed here.

Table 4-5

Medium- and Heavy-Duty Alternative Fuel Engines (listed vehicles were available as of mid-1993 as production models, or were expected to be in production in the next several years in the absence of specific regulatory or economic impetus[1])

Fuel	Manufacturer	Engine	Typical Application
Methanol[2]	DDC	6V-92TA, 253HP*	Urban Bus, Some Off-Road
		6V-92TA, 277HP*	Urban Bus, Some Off-Road
		6L-71TA	Primarily Off-Road
		4L-71TA	Primarily Off-Road
Ethanol (E95)	DDC	6V-92TA, 253HP*	Urban Bus, Some Off-Road
		6V-92TA, 277HP*	Urban Bus, Some Off-Road
Natural Gas	Caterpillar	3306, 250HP	
		3406, 350HP	
	Cummins	L10, 240HP	
		L10, 270HP	
		6B, 195HP	
	DDC	6V-92TA, PING 253HP	
		6V-92TA, DING 253HP	
		6V-92TA, PING 277HP	
		6V-92TA, DING 277HP	
		6V-92TA, PING 300HP	
		6V-92TA, DING 300HP	
	GM	8.2L, 175HP	
	Tecogen/GM	4.27, 213HP	
	Hercules	3.7L, 130HP	
		5.6L, 190HP	
	Mercedes-Benz	M 366G, 148HP	
	Navistar	7.3L, 210HP	
	Tecogen	TecoDrive 7000	
	Volvo Bus Corp.	9.9L, 250HP	
Propane	Ford	429 CID Truck	
		F-600	
		F-700	
	GM	366/427 CID Truck	
		5.7L, pick-ups, vans, suburbans, Convert on delivery	
	Iveco	240HP	
	Mercedes	220HP	

Notes:

1) Based on conversations with OEMs, only DDC will supply alcohol heavy duty engines in the absence of large demand. DDC has essentially no lower production limit. Caterpillar and Navistar, the two other OEMs well positioned to offer methanol engines, are not yet certified and would only respond to a large demand, on the order of thousands of sales per year.
2) DDC engines certified on M100, M85, and M99 with 1% avocet.

* Engines are fully certified and available for sale.

In addition, since methanol can be produced by the gasification of coal, the Hawaiian Electric Company (HECO) has studied the installation of a coal gasifier at the Kahe Point station which could produce methanol using Babcock and Wilcox technology.

Technology for the commercially successful production of methanol from biomass may be ready in the near- to mid-term. The production scale of commercially feasible biomass to methanol facilities is expected to be relatively large (on the order of 100 million gallons per year) to spread the cost of the necessary equipment over a relatively large volume.

4.2.1.2 Methanol Vehicle Availability by Sector

4.2.1.2.1 Ground Sector

In the 1980s, manufacturers began to deploy small numbers of methanol cars, particularly in California where interest in very low emission vehicles encouraged a detailed look at clean alternative fuels. Methanol appeared to have a chance of becoming an acceptable substitute for gasoline based on its performance and projected cost. However, as these vehicles were "dedicated" vehicles which could not operate on gasoline, they did not attract much user interest due to the limited number of methanol refueling stations and their reduced range.[5]

The adoption of the Alternative Motor Fuels Act credits in 1988 (the Alternative Motor Fuels Act is discussed in Section 4.3.1) added impetus to interest in methanol. Flexible-fuel[6] technology developed as a response to limited methanol availability at refueling stations. In 1988, the Department of Business, Economic Development and Tourism (DBEDT) and the Hawaii Natural Energy Institute (HNEI) began a demonstration of seven M85 vehicles. Ford deployed 210 flexible-fuel Crown Victorias in California and elsewhere in 1989 and 1990 and 180 1991 flexible-fuel Taurus sedans. GM placed 200 1991 Chevrolet Luminas. Volkswagen placed slightly more than 300 flexible-fuel Jettas. In 1992, Ford provided 200 flexible-fuel Econoline vans or Club Wagons, and Chevrolet placed 1,200 flexible-fuel Lumina sedans. Other manufacturers provided small numbers of vehicles as well.

In 1993, Chrysler won a major contract with the General Services Administration (GSA) under the Alternative Motor Fuels Act for 2,500 flexible-fuel Plymouth Acclaim and Dodge Spirit sedans, of which 500 were to be deployed in California. Ford also accepted orders for 2,500 1993 Taurus sedans, and Chevrolet and Chrysler had campaigns to place as many Luminas, Acclaims, and Spirits as possible. Orders for these cars may have amounted to roughly 1,000 vehicles. Prior to these introductions, about 8,000 methanol fuel flexible vehicles (FFVs) were operating in California. Also in 1993, DBEDT and HNEI began another methanol FFV demonstration program.

In the 1995 model year, Ford offered the Taurus in both ethanol-and-methanol-flex fueled versions. Chrysler offered the Dodge Spirit, Plymouth Acclaim and Dodge Intrepid. Manufacturers have been vague about future plans. Privately, they indicate that the need to demonstrate flexible-fuel technology has been met, and that customer responses have been studied to an extent sufficient to plan future marketing strategies. Continued manufacture of

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[5] Unless the manufacturer supplies a larger fuel tank, methanol vehicles tend to have a reduced range because the energy density of methanol is about half that of gasoline.

[6] A flexible-fuel (or variable-fuel) vehicle is one that can burn variable blends of two or more fuels.

2,000 to 4,000 FFVs per year is not economical. Thus, although manufacturers could supply a substantial number of methanol/gasoline light-duty vehicles, they will not be likely to do so except to meet the Energy Policy Act (EPACT) requirements which began in the 1993 model year. Given these observations, it is the conclusion of most observers that the automakers would devote themselves to preparing for the government fleet sales requirements of EPACT.

Methanol engines and vehicles are also available in the heavy-duty sector. Detroit Diesel Corporation (DDC) produces methanol 6V-92TAs. The 253 horsepower (hp) and 277 hp versions are emission-certified on M85, M100, and M99 with one percent Avocet.[7] This engine dominates the urban bus market.[8] DDC has stated it would sell even small numbers of methanol 6V-92TAs each year because its development costs have been spent and its strategy is now to sell such engines even in small numbers (Miller, 1993).

Vehicles are less available between 6,000 pounds and 26,000 pounds (classes 3 through 6). This may be rectified to some degree by DDC's recent development of a methanol/Avocet version of their 4-71 engine which, as part of a demonstration program, will be installed in 10,000 pound to 12,000 pound school buses in Sacramento.[9] DDC has stated that suitable methanol engines could be commercialized quite easily with sufficient demand (Miller, 1993).

Other manufacturers such as Caterpillar and Navistar[10] have developed to near-commercial stages methanol versions of heavy-duty engines that serve a large segment of the truck market. However, they do not expect to make these engines commercially available because they do not see a growing market for heavy-duty methanol vehicles and need an annual demand of thousands of engines before committing to production (Baranescu, 1993; Gove, 1993).[11]

4.2.1.2.2 Air And Marine Sectors

Ship engines could be designed to operate on methanol, but since alcohols are miscible with water, there is concern that, on-board a ship, water would contaminate an alcohol fuel and introduce salt into the engine. In addition, regulations have not been established nor are expected which would require alternative fuel engines for marine applications. With respect to alcohol-fueled aircraft, the focus is on ethanol (see Section 4.2.2).

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[7] Avocet is a proprietary additive package that includes an ignition improver, a lubricating additive, and a corrosion inhibitor.

[8] The 6R-92TA engine is appropriate for Class 7 and Class 8 trucks. However, it is not currently sold into the truck market. DDC is attempting to break into the truck market with this methanol engine and has 300 hp and 350 hp versions of the methanol 6V-92TAs operating in the current California Energy Commission (CEC) heavy-duty truck demonstration in Southern California. DDC is also demonstrating a methanol 300 hp 6L-71 engine as part of the CEC program, but this engine series is not typically found in trucks either. Both engines are used to power off-road equipment.

[9] The 4-71 is typically used in off-road equipment.

[10] Methanol versions of the diesel 3306 and 3406 DITA engines have been developed and demonstrated. A methanol DT-466 has been developed and demonstrated.

[11] There have been difficulties reported during the Los Angeles County Metropolitan Transportation Authority's methanol transit bus demonstration program, the nation's most ambitious methanol bus program. However, a staff assessment has concluded that the mechanical difficulties associated with the introduction of the methanol buses were not substantially different or more serious than mechanical difficulties experienced in the past with the introduction of a new diesel bus design. Few of the problems were fuel-related.

4.2.1.3 Conclusions

For the purpose of this analysis it is assumed that enough methanol flexible-fuel light duty vehicles will be available through the 1990s to satisfy fleet demands under the AFV purchase requirements of EPACT.[12]

4.2.2 ETHANOL

4.2.2.1 Introduction

Ethanol, CH_3CH_2OH, is produced from ethylene or biomass. Ethylene is derived from natural gas or petroleum in large volumes worldwide. Biomass has been fermented to produce ethanol for thousands of years. Any substance which contains sugar or can be converted to sugar (such as starch or cellulose) may be used as the biomass feedstock. In addition to being used as a fuel and as a beverage, ethanol can be used as a solvent or in the manufacture of drugs, plastics, lacquers, perfumes, and other products (Encyclopedia of Chemical Toxicology, 1980).

Like methanol, ethanol is well suited to be a motor fuel. Its high octane permits its use in high compression engines, resulting in increased efficiency and power output. Ethanol can be used in motor vehicles in a number of forms, including:

- Gasohol or E10 (ten percent ethanol, 90 percent gasoline);
- "Diesohol" or E30 (30 percent ethanol, 70 percent diesel);[13]
- E85 to E95 ("neat ethanol") (85 percent to 95 percent ethanol, five percent to 15 percent gasoline or other hydrocarbon); and
- Ethyl Tertiary Butyl Ether (ETBE), an oxygenate made from ethanol which can be blended in small amounts with gasoline to reduce emissions and enhance octane.

The United States produced about 875 million gallons of fuel ethanol in 1991 and has been exporting fuel ethanol to Brazil since 1989.[14]

One inoperative ethanol plant now exists in the state on Maui. The facility was originally built for rum manufacture but has been inoperative since 1985. The capacity of the plant is about one million gallons of ethanol per year. A two million gallon per year facility, originally built for ethanol production but later used to make rum from molasses, was built in 1985 at Campbell Industrial Park on Oahu. This facility was recently dismantled (Shigeta, 1993).

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[12] These purchase requirements are considered to be modest, and are discussed in more detail in Section 4.3.1.

[13] Diesohol is not yet a proven fuel. Preliminary work indicates that a blend of 30 percent ethanol and 70 percent diesel, including some additives, could be used directly in an unmodified diesel engine (Holland et. al., 1992).

[14] In 1975, Brazil embarked on a large program to displace petroleum in their ground transportation sector by ethanol, and has been able to achieve 50 percent substitution. There are now more than four million ethanol vehicles in Brazil.

Prospects for ethanol production in Hawaii may now be brighter because of such factors as the following:

- Since sugar cane is a good feedstock for ethanol, the infrastructure for cane production already exists, and gasoline blended with low levels of ethanol may be used in unmodified gasoline engines, ethanol production is seen by some as a near-term way to support the agriculture industry.
- Grants from the National Renewable Energy Laboratory were recently awarded to the Pacific International Center for High Technology Research in association with others[15] to evaluate new technology for ethanol production from bagasse in Hawaii.
- Entrepreneurs continue to approach the state for support in developing ethanol facilities.

The commercial feasibility of ethanol production is related to the price of petroleum and technological improvements to increase yield. Policy aspects of state support for ethanol production are discussed further in Chapter 10.

4.2.2.2 Ethanol Vehicle Availability by Sector

4.2.2.2.1 Ground Sector

The vehicle technology for methanol and ethanol is essentially the same, differing only in the calibration of the fuel delivery system and fuel composition sensor (Barnes, 1993).[16]

In fact, converting a methanol vehicle to run on ethanol would only involve essentially software changes. The conversions could potentially be performed at a dealer's shop.[17]

General Motors (GM), Ford and Volkswagen have completed the testing necessary to optimize their FFVs to run on E85. GM provided 50 flexible-fuel Chevrolet Luminas calibrated for ethanol operation that are being demonstrated in the Midwest, and converted two M85 vehicles for the California program. Volkswagen produced 1992 Jettas that would run on E85. Ford's 1995 Taurus is available with methanol and ethanol flexible fuel options. In 1996, GM will offer ethanol flexible-fuel pickup trucks.

Gasoline blended with low levels of ethanol (gasohol) can be used in unmodified engines. Gasohol use has been widespread since the oil crisis of the 1970's, and all major vehicle manufacturers include gasohol under their warranty coverage (State of Hawaii, Department of Business, Economic Development and Tourism, 1991). Another way to incorporate relatively low levels of ethanol into unmodified engines is through ETBE, a fuel oxygenate that satisfies air quality requirements on the mainland.

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[15] AMOCO, Cargill, C. Brewer, HELCO, HEI, Hawaii County, UH, HNEI and the Hawaii Agricultural Research Corporation.

[16] Three-way FFVs (methanol, ethanol and gasoline) could perhaps be developed. SAAB has performed research, but efforts have been frustrated by the need for a fuel composition sensor capable of measuring relative amounts of ethanol, methanol, and gasoline (Barnes, 1993).

[17] The conversion would include changing the "chip" that integrates the signal from the alcohol sensor with engine performance. The manufacturer's cost of conversion may be $40, especially if large numbers of vehicles were being converted.

Preliminary indications are that a blend of 30 percent ethanol and 70 percent diesel ("diesohol") could be used in unmodified diesel engines.[18] Full-scale durability and field testing has not yet occurred, however (Earle, 1993).

DDC has certified its 253 hp and 277 hp 6V-92TA for E95. Fourteen transit buses using this engine are in operation in Peoria, Illinois. Little ethanol development of heavy-duty truck engines has occurred, however.

4.2.2.2.2 Air And Marine Sector

Ethanol engines for marine vessels are not expected for the reasons described in Section 4.2.1.2.2. Recently, however, an aircraft engine series was certified on ethanol.[19] It is not expected, however, that aircraft regulations would encourage the production of alternative fuel aircraft engines on a significant scale.

4.2.2.3 Conclusions

Because of the basic convertibility of methanol and ethanol FFVs, the availability of ethanol FFVs could match the availability of methanol FFVs. However, a petroleum substitution strategy has to adapt to the vehicles that manufacturers provide, and of the two alcohols, most FFVs are being manufactured for methanol.

4.2.3 NATURAL GAS AND SYNTHETIC NATURAL GAS

4.2.3.1 Introduction

Commercial natural gas is a blend of gases, mostly methane (CH_4) but also ethane, propane, butane and small amounts of other gases.

Most natural gas is produced from oil and gas-producing wells. Methane is also produced by the anaerobic decomposition of biomass, such as occurs in landfills and sewage treatment plants. Sometimes this methane is recovered and used.

Natural gas is an excellent vehicle fuel, burning very cleanly with a high octane value permitting efficient high-compression engines. However, it is difficult to store enough natural gas on a vehicle to provide adequate range. Since the amount of energy in a cubic foot of natural gas at ordinary pressure is very low, the gas must either be stored as compressed natural gas (CNG) at very high pressures (generally between 2,400 pounds per square inch and 3,600 pounds per square inch), or as liquefied natural gas (LNG) at very low temperatures. Therefore, natural gas appears best suited for medium-duty and heavy-duty trucks and buses, where fuel storage volume is more easily provided than in smaller vehicles.

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[18] Greenbranch Enterprises has performed testing of this blend, which includes a proprietary additive, with favorable results.

[19] Researchers at Baylor University in Waco, Texas, certified an aircraft engine series on ethanol in March, 1990. FAA certification is required for an engine to be used in civil commercial applications. The engine used for testing was a 260 horsepower (2,700 rpm) Avco Lycoming AE1IO-540 D4A5 engine with 6 cylinders, parallel valves, and fuel-injection (Ninth International Symposium on Alcohol Fuels, Volume 2).

Hawaii does not have natural gas. Oahu has a fuel gas locally known as "synthetic natural gas" or SNG. This gas is distributed by pipeline to a relatively small number of customers in a limited area of Honolulu.

The chemical composition of local SNG is highly variable, being a blend of refinery byproducts in stock at the time mixed to achieve a relatively constant energy content. This SNG could not be used as a motor fuel. Although some methane could be produced from landfills and sewage treatment plants, volumes would be small and the methane would not have the competitive pricing with petroleum that it has on the mainland. Natural gas on a commercial scale would need to be imported, and the development of infrastructure to support the importation of natural gas is not expected (State of Hawaii, DBEDT, 1993).

4.2.3.2 Natural Gas Vehicle Availability by Sector

4.2.3.2.1 Ground Sector

Manufacturers believe that on the mainland, natural gas will be a formidable competitor of petroleum outside of the light-duty passenger automobile category.[20] Therefore, the manufacturers are beginning to offer a fairly wide range of buses, vans, wagons, and pick-up trucks. Hundreds of transit buses around the nation are now operating on natural gas.[21] Chrysler plans to supply natural gas vans and wagons in the B250/B350 series and Chevrolet will supply C1500 series pick-up trucks (gross vehicle weight 6,100 pounds). Cummins has recently certified in California a natural gas version of its L10 engine.

Ford has shown several natural-gas versions of the Crown Victoria sedan, and Chevrolet will also supply several thousand natural gas versions of the compact Corsica sedan.[22] However, the ability to store sufficient fuel onboard is a significant problem for passenger cars. Ford recently announced a $50 million program to develop dedicated natural gas passenger cars by the mid 1990s, but these cars would not go into production for several years (New Fuels Report, 1993).

4.2.3.2.2 Air And Marine Sector

A few natural gas vessels are or will soon be operating around the U.S.: an LNG supply boat and CNG crew boat are in construction in Santa Barbara, California, and a CNG ferry boat is in operation on the Chesapeake Bay. However, no factors are motivating the production of natural gas-fueled marine engines. There are rumors of an LNG-fueled U.S. military jet (Spy in the Sky, 1992).

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[20] It appears likely that EPACT requirements for fleet purchase requirements in the light-duty truck sector from about 4,000 pounds gross vehicle weight (GVW) to the EPACT upper limit of 8,500 pounds GVW will be met primarily by natural gas and propane. EPACT's requirements are described in Section 4.3.1.

[21] For example, Sacramento Regional Transit recently acquired 75 new buses powered by Cummins L10 CNG engines. Houston Metro currently operates 60 LNG transit buses (Houston Metropolitan Transit Authority, 1993). The Metropolitan Transit Authority in New York City operates CNG buses.

[22] Each Corsica will have, in addition to the conventional gasoline tank, a storage capacity for natural gas equivalent to four gallons of gasoline. This apparently illogical product, having such a limited onboard storage capacity for natural gas, is interpreted as a response to GSA desires to fill out the orders in the 1993 EPACT procurement with natural gas vehicles.

4.2.3.3 Conclusions

Natural gas vehicles will be available in increasing number and model lines in weight classes around 6,000 pounds and over from now through 2014. However, with no natural gas supply system likely to be developed in Hawaii, natural gas AFVs do not appear feasible here. The lack of a role for natural gas vehicles in Hawaii is a significant difference from the alternative fuel picture that is developing on the mainland.

4.2.4 PROPANE

4.2.4.1 Introduction

Commercial LPG, a blend of propane (C_3H_8) and other liquid hydrocarbons, is commonly referred to as simply "propane". Hawaii consumes about 30 million gallons of commercial propane each year, most of which is produced as a refinery byproduct, but some of which is imported (Freeman, 1992). Imported propane is also a refinery byproduct but can also be produced from liquids obtained from gas and oil wells. In Hawaii, propane is trucked to storage tanks for pipeline distribution for cooking, water heating, and other uses. Propane is also dispensed in small containers to serve other fueling needs, such as barbecue grills. If all of this propane were used as a vehicle fuel, it could power about 50,000 light-duty vehicles.

Propane is an excellent motor fuel. It is clean burning and has a high octane value. Although it is a gas at room temperature and normal pressure, it condenses to a liquid at pressures around 100 pounds per square inch and is therefore readily storable in simple metal bottles. It has an energy density similar to that of gasoline, and therefore does not produce a significant range penalty compared with an equal volume of gasoline. In contrast to the mainland, propane in Hawaii is slightly more expensive than gasoline per unit of energy.

Vehicles can be built to use propane, or gasoline vehicles can be converted to burn propane. The cost of a propane conversion is about $1,200 to $2,000 per vehicle.

There are roughly 400,000 propane vehicles in the U.S., and perhaps as many as 3,000 in Hawaii (Freeman, 1992) including school buses, Handi-Van vehicles, cars, trucks, airport support vehicles and forklifts. The City and County of Honolulu has 30 years of experience with propane in transportation, and presently there are 139 city vehicles, or 11.5 percent of the City's fleet, using propane.

In the drafting of the Alternative Motor Fuels Act, propane was regarded as primarily a petroleum product rather than a true alternative fuel. This interpretation was changed in the 1992 National Energy Policy Act and propane was made eligible for the incentive treatment in the calculation of corporate average fuel economy (CAFE).

4.2.4.2 Propane Vehicle Availability by Sector

4.2.4.2.1 Ground Sector

Original equipment manufacturers[23] (OEMs) offered a few models of propane-ready light trucks in the 1970s because of the economic advantages of propane in some high-mileage applications. When oil prices fell in the 1980s, OEMs ceased to offer propane-ready vehicles, although many conversions of gasoline and diesel vehicles by aftermarket converters continued to take place.[24]

Presently propane is used to fuel vehicles such as pick-ups, vans, medium duty trucks and buses, and forklifts. Many of the older vehicles are converted from gasoline, but manufacturers are now offering some propane-ready vehicles for upfitting. The vehicles would be covered by OEM warrantees and service plans.

Both natural gas and propane are well suited to aftermarket conversions, which have provided by far the greatest number of these vehicles. In the U.S., future conversions will be complicated by greatly elaborated requirements for emissions certification. If the California proposal is a model, certification will require durability testing, as well as the acceptance of responsibility for warranties and potential recalls for defects related to emissions control components. Future conversions may be done in close conjunction with the original vehicle manufacturer, if at all. Therefore, conversions may not play a long-term role in the production of AFVs, although they are likely to be important in the near term.

4.2.4.2.2 Air And Marine Sectors

No developments in propane use in the air or marine sectors have been identified.

4.2.4.3 Conclusions

A variety of propane vehicles are available, either through conversion or as OEM vehicles. There is long experience with the technology worldwide, and Hawaii has experience with propane vehicles, most of which were produced through conversions. In fact, the City and County of Honolulu are proposing to convert 364 additional propane vehicles over the next seven years to help satisfy their National Energy Policy Act requirements (National Energy Policy Act requirements are described in Section 4.3.1).

Increased propane demand in the ground transportation sector would need to be satisfied by increasing imports of propane, increasing local refinery production (which would require increased importation of petroleum), or a redirection of the fuel away from current non-transportation consumers.

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[23] OEMs describe the vehicle as produced at the manufacturing plant.

[24] Aftermarket conversion is the process by which independent parties not associated with the original vehicle supplier install equipment to enable the vehicle to operate on other fuels.

4.2.5 ELECTRICITY

4.2.5.1 Introduction

"Electric vehicles" (EVs) are broadly defined as those which are propelled by electric motors. EVs come in many forms, such as:

- battery-powered vehicles ("battery-electric vehicles");
- "hybrid" vehicles that use more than one form of energy storage and/or more than one form of propulsion;
- fuel cell vehicles that convert chemical energy directly to electric power; and
- vehicles powered by on-board solar cells.

EVs would allow transportation energy to be obtained from any fuel capable of producing electricity, such as fossil fuels, organic wastes, wind, solar, geothermal, and others. Which fuel would actually be used to power EVs is complicated, affected by such factors as:

- the time of day at which the recharging occurs;
- fuel prices;
- purchase agreements with independent power producers (IPPs); and
- the island on which EV recharging is proposed.

At present, much of the increased electricity would come from petroleum. On Oahu, some portion of the power could come from municipal solid waste (the H-POWER facility) and coal, and on the neighbor islands, some portion could come from biomass (such as bagasse-fired power generation units), hydroelectric, wind, and geothermal sources. Non-petroleum energy sources are currently under-utilized on Oahu and Hawaii during early morning hours when EV recharging is expected to occur.

In addition to their flexibility in fuel, EVs offer other advantages including:

- they can recover and store energy "wasted" during braking (regenerative braking);
- the power demand of an EV is greatly reduced when the vehicle is not traveling (stuck in traffic congestion);
- EVs do not emit air pollutants, a significant feature in downtown areas with poor air quality;[25]
- EVs are extremely quiet in comparison to internal combustion (IC) vehicles;[26]
- EVs are expected to have reduced maintenance in comparison to an IC vehicle; and

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[25] While combustion and resultant air emissions may have occurred to produce the electricity, the pollutants are emitted from the power plant stack which may be located in an area where air quality is not as great a concern as in a downtown location. It is also feasible and effective to place air pollution controls on the generating station stack.

[26] EVs are so quiet, in fact, that this may be a safety concern since people are accustomed to using a vehicle's sound as a cue to its approach.

- EVs may be amenable to small-scale manufacturing, since they are much simpler than an IC vehicle.[27]

Current barriers facing EVs include:

- their cost;[28]
- lack of standardization of such items as recharging systems, components, and batteries;
- lack of trained users and mechanics;
- public and fleet manager perceptions;
- issues associated with battery recycling;
- the lack of recharging infrastructure; and
- the poor ability to store sufficient energy on-board to provide both long range and peripheral features consumers want, such as air conditioning.

Battery-electric vehicles held significant U.S. market share in the earliest days of the automobile, but after the invention of the electric starter system for gasoline vehicles, the electric vehicle receded into small niche applications.

Vehicle applications appearing most likely for battery-powered EVs[29] include:

- small vehicles used in a localized area, such as Cushman three-wheelers used for parking enforcement or vehicles used in "new village" layouts,[30] industrial/commercial parks or retirement communities;
- "station cars" (cars that shuttle between home and a transit station);
- short-range commuter cars, vehicles used for short trips, shopping, short home-to-work commutes, etc.;
- delivery vans which experience substantial "stop-and-go" operation; and
- shuttle buses.

These are appropriate applications for initial EV deployment because range would not be a serious limitation, and the vehicle would return to a home base where a recharging station could be provided.

Hybrid vehicles combining electric drive and internal combustion engine systems show promise, and several vehicles of this type are being deployed in Hawaii as part of the Hawaii Electric Vehicle Demonstration Program (HEVDP). The engine on a hybrid vehicle (typically called an auxiliary power unit or APU) is operated over a narrow range of speeds, allowing

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[27] For example, EVs are being made on the Big Island (see footnote 33) and a Japanese firm, Itochu Corporation, has invested in U.S. Electricar, Inc., which expects to open a facility to convert conventional vehicles to EVs in Hawaii as part of the HEVDP.

[28] EVs are currently much more costly than conventional vehicles. EV offerings from major manufacturers in the late 1990's may be as much as $10,000 more than conventionally fueled counterparts (Nichols, 1993). The pace at which costs will fall is a matter of intense disagreement between EV advocates and detractors. Additional EV cost information is provided in Chapter 6.

[29] Although many golf carts are electric, they are not legally classified as "motor vehicles" and, therefore, are not included in any of the proposed alternative fuel vehicle programs or incentives.

[30] New village land use planning concepts are discussed in Chapter 3.

optimization of performance and emissions characteristics compared to conventional IC engines. APUs could use gasoline, diesel or alternative fuels. For example, the 40-feet transit bus being deployed as part of the HEVDP is a hybrid electric equipped with a propane-fueled rotary engine. The range extension and performance boost provided by the on-board engine on hybrids may greatly enhance consumer acceptance of electric vehicles.

Hybrid-electric vehicles could have appeal in relatively heavy duty applications such as transit buses and trucks.

Fuel cells that combine gaseous or liquid fuels with oxygen in a chemical reactor to produce electric energy are currently in use as stationary power generators, and the U.S. Department of Energy (U.S. DOE) has researched fuel cells in transportation since 1987. In common with internal combustion (IC) vehicles, fuel cell systems require that chemical energy be stored on the vehicle. Gasoline, alcohol or propane are all suitable for fuel cells. Size and weight constraints, in addition to infrastructure and economic obstacles, need to be addressed before fuel cells can become a viable transportation technology. The U.S. DOE's program aims for sales of "first-generation" fuel cell vehicles by 2005 and sales of "fully competitive" fuel cell vehicles by 2011 (U.S. DOE, 1992c).

Some of the most "visible" electric vehicles are those powered by on-board panels of solar cells. These vehicles are often hand-crafted and designed to compete in solar car races. These vehicles have much to contribute to research and development, but they are not designed to meet the needs of commuters or fleets.

4.2.5.2 Electric Vehicle Availability

Much research, funding, and enthusiasm is being devoted nationally and locally[31] to developing practical electric vehicles, and the technology is developing rapidly with substantial government support. For example, areas of active research include:

- enhancing range;
- decreasing the time required to recharge;
- increasing battery life;
- increasing battery storage capacity;
- developing "flywheel" energy storage devices;
- developing full-featured vehicles;
- decreasing maintenance; and
- improving battery recycling technology.

OEMs have developed a few prototype or limited production vehicles, and are working to develop marketable production vehicles to satisfy the EV sales requirement in California of

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[31] DBEDT and the Department of Education started sponsoring solar vehicle competitions in 1988, and Hawaii hosted the national "EV '93" conference, which included the Pali challenge, a road rally of EVs over the Pali.

two percent of all light-duty sales beginning in 1998 (this requirement is discussed in Section 4.3.2). There are also many EVs being produced by specialty car companies.[32]

There are several governmental programs investing in EV research and development, such as the HEVDP sponsored by the Advanced Research Projects Agency (ARPA) of the U.S. Department of Defense. ARPA provided $5 million of federal funds and other project participants provided $5.5 million in matching funds in the first year to demonstrate 37 EVs on Kauai, Oahu, Maui, and the island of Hawaii, including such vehicles as transit buses, pick-up trucks, vans and sedans. This program is funding the establishment of the National EV Data Center at the University of Hawaii, and an electric vehicle facility on Cooke Street. In addition, the U.S. DOE has devised a multi-year program to assist industry to develop hybrid vehicles which meet consumer demands to the extent sufficient to make production financially worthwhile. According to this plan, production hybrid vehicles would be available by 2001 (U.S. DOE, 1992b).

4.2.5.3 Conclusions

Hawaii has a mild climate that favors battery performance, limited vehicle range requirements, and a large supply of renewable energy resources capable of producing electricity. High levels of traffic congestion such as found in Honolulu also favor electric vehicles because they consume only the energy required to run peripheral devices (such as air conditioning) while stopped in traffic. Thus, Hawaii may offer more opportunities for electric vehicles than any other state. The promise of EVs is so attractive, and the governmental support of research and development is so strong, that future EVs may well compete successfully with IC vehicles in at least some applications. In the near term, however, issues such as vehicle cost and potential consumer concerns about the availability of opportunity charging remain significant barriers to deployment.

4.2.6 BIODIESELS

4.2.6.1 Introduction

Biodiesel is a vegetable-oil or tallow-based fuel with properties similar to diesel. The oils are typically obtained from oil seed crops such as rapeseed (in Europe) or soybeans (in the US), although other oil sources may be used, such as waste oil from fast food restaurants, fats from meat processing operations, and tropical oils. Several proprietary names exist, such as SoyDiesel, the product associated with the Missouri Soybean Merchandising Council, and Diesel-Bi, a product of the Ferruzzi-Montedison Group subsidiary, Novamont.

Biodiesel manufacturers recommend that it be blended with petroleum-derived diesel fuel in a blend of about 20-30 percent. This blend can be used in unmodified diesel engines, but biodiesel can erode rubber so rubber fuel lines are typically replaced, and injection timing should be adjusted (Ayers, 1993). In the U.S., trucks, buses, and a boat have all been operated on biodiesel. In Europe, Mercedes-Benz warrantees its heavy-duty engines on biodiesel (Missouri Soybean Merchandising Council and Missouri Soybean Association, 1992).

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[32] Such as U.S. Electricar and the Suntera Solar Chariot Company of the Hamakua District of the Big Island. Suntera recently received state support for a bond issue. Suntera and U.S. Electricar are members of the HEVDP.

Biodiesels from non-waste oils are considerably more expensive than diesel. Biodiesel from used cooking oils could be considerably less expensive, although quantities would be limited.

4.2.6.2 Biodiesel Fuel Use in the Ground and Marine Sectors

Field tests to date have shown good performance, and have included the use of biodiesel in transit buses, utility vehicles, and trucks in Sioux Falls, South Dakota and St. Louis, Missouri. The Sunrider, a SoyDiesel powered marine vessel, completed a round-the-world expedition in September, 1994. Some use of biodiesel has been achieved in Europe through incentives and mandates.

4.2.6.3 Jet Fuel From Biomass

Biodiesel is a possible candidate for petroleum substitution as a commercial jet fuel. Its high cetane number (less than 50), low sulfur (reflecting the absence of sulfur in most biomass feedstock) and low aromatics content (resulting in low particulate emissions) makes it an attractive alternative to petroleum.

4.2.6.4 Conclusions

Biodiesel appears to be a very feasible substitute for diesel in both the ground and the marine sectors, requiring minimal engine modifications. The main barrier to biodiesel is its high cost, which depends in large measure on the feedstock price. The Honolulu Public Transit Authority (HPTA) has determined that a 25 percent biodiesel blend would increase their fuel costs by 33 percent.

4.2.7 HYDROGEN

Hydrogen powered vehicles have been built, but they are not expected to be commercially available soon.

4.3 FACTORS PROMOTING ALTERNATIVE FUEL USE IN MOTOR VEHICLES

4.3.1 FEDERAL POLICIES, PROGRAMS AND LEGISLATION

Because of the economics of petroleum-based fuels in the U.S., the free market alone has not produced much use of alternative fuels in the transportation sector. During periods of very high oil prices and uncertainties about oil supply, propane and natural gas have made slight inroads. When oil prices decline, interest in alternative fuels also declines, except in a few niches.[33] Therefore, in the U.S., legislation has been used to promote development and use of alternative fuel technologies.

Oil price and supply uncertainties of the 1970s stimulated passage of the Energy Policy and Conservation Act of 1975. This Act established a roll-in of fuel economy standards beginning with the 1978 model year (the Corporate Average Fuel Efficiency, or "CAFE" standards) with the intent of reducing oil imports. The fuel economy standard is now at 27.5 miles per gallon, and has slowed growth of oil use in transportation.

The Alternative Motor Fuels Act (AMFA) of 1988 allowed vehicles using alternative fuels to compute their fuel economy on the basis of gasoline consumed. The computation procedure[34] results in these vehicles having a gasoline fuel economy of 80 miles per gallon or more. The Alternative Motor Fuels Act was an explicit use of the fuel economy standards to encourage manufacturers to build AFVs. The Act was expected to be influential in shaping manufacturer choices because, at the time, the fuel economy standard appeared difficult to meet, especially for domestic manufacturers who had many customers who expected large vehicles. The Alternative Motor Fuels Act also required that federal fleets purchase AFVs to provide some market demand, and to serve as an example in fuel substitution. In some cases, Executive Orders exceeded the Alternative Motor Fuels Act requirements.

Financial incentives have been offered since the early 1980s for ethanol to be used as a motor fuel.[35] Incentive payments between 1987 and 1992 ranged from $445 million to $540 million per year. With these incentives, ethanol has captured about one half of one percent on an energy basis of the national consumption of motor fuel.

In 1992, Congress passed the EPACT, the strongest national statement ever made in support of alternative fuels. The EPACT sets national goals of replacing with alternative fuels 10 percent of conventional fuels by 2000, and 30 percent by 2010. The EPACT had a further goal that half the substitute fuels be of domestic origin.[36]

To meet this goal, the EPACT requires certain fleets, including those in Hawaii, to purchase AFVs in increasingly large numbers. The requirements, summarized in Table 4-6, target centrally fueled fleets of light duty vehicles up to 8,500 pounds (federal and state fleets and the fleets of businesses producing alternative fuels). Municipal and private fleets of light-duty vehicles may be targeted if national goals are not being met at certain milestones. The fleet requirements could yield about three percent substitution of petroleum fuels by 2010, although exemption provisions make a definitive estimate difficult.

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[33] Propane continues to hold a small market share in high mileage fleet vehicles, including some taxi and van fleets, even during periods of low oil prices.

[34] The alcohols were assumed to be used in the form of 85 percent alcohol and 15 percent gasoline, and flexible-fuel and dual-fuel vehicles were treated as running on alcohol half the time.

[35] Currently the incentive is a waiver of 5.4 cents of the federal excise tax on gasoline for blends of ten percent ethanol and 90 percent gasoline ("gasohol"). Alternatively, an income tax credit of 54 cents per gallon of ethanol can be claimed. Small producers (less than 30 million gallons per year) can claim an additional ten cents per gallon income tax credit.

[36] Defined to include nations with which the U.S. has free trade agreements.

Table 4-6

National Energy Policy Act Fleet Purchase Requirements for New and Replacement Vehicles Which Must Be AFVs

	Federal Fleets[1]	State Fleets[2]	Fuel Provider Fleets[3]	Private and Municipal Fleets[4]
1993	5,000			
1994	7,500			
1995	10,000			
1996	25%[5]	10%	20%	
1997	33%	15%	50%	
1998	50%	25%	70%	
1999	75%	50%	90%	20%
2000	75%	75%	90%	20%
2001	75%	75%	90%	20%
2002	75%	75%	90%	30%
2003	75%	75%	90%	40%
2004	75%	75%	90%	50%
2005	75%	75%	90%	60%
2006+	75%	75%	90%	70%

Source: National Energy Policy Act, 1992.

Notes:
1) Section 303(a); years = fiscal years.
2) Section 507(o); years = model years; conversions may be used instead.
3) Section 510(a); business or units whose principal business is to provide alternative fuels, or a producer of electricity, or an oil refinery, importer, or producer of at least 50,000 bpd if a substantial portion of the business is producing alternative fuels; year = model year; two year slip available for electric utilities purchasing electric vehicles.
4) Section 507(a); goals may be adjusted downward or slipped; invoked only if goals of 10% substitution by of 2000 and 30% substitution of 2010 are not projected to be met and practical and if fuels are available; alternative schedule starting in 2002 can be involved later if needed; years = model years.
5) Percentages refer to portion of new and replacement vehicles which must be capable of using alternative fuels.

The fleet purchase requirements are "fuel neutral" since they do not specify particular alternative fuels.

The EPACT also includes some financial incentives, summarized in Table 4-7, for vehicles up to 26,000 pounds and buses carrying 20 or more passengers. These incentives focus on offsetting initial capital expenditures for AFVs and fuel storage and dispensing equipment. These incentives appear to favor propane and natural gas over alcohol.

The Intermodal Surface Transportation Efficiency Act (ISTEA) was adopted in 1991 and continues the practice of the Federal Transit Authority (FTA) in assisting with the incremental costs of alternative fuel buses and fuel storage and dispensing equipment. The EPACT also authorizes funds for alternative fuels in transit applications.

Executive Order 12844 was signed on April 21, 1993 and increases by 50 percent the AFV purchase requirements for federal fleets as required by EPACT for 1993, 1994 and 1995.

Another federal program, the "Clean Cities Program," is a voluntary program whose goal is to increase the number of AFVs throughout country and encourage the development of refueling infrastructure for alternative fuels. Cities wanting to be designated a "Clean City" are required to execute a Memorandum of Understanding signed by "stakeholders" and develop an implementation plan to increase the number of AFVs in the city. As of early 1994, there were six designated "Clean Cities." While not yet designated a "Clean City," Honolulu has an active program[37] which is working to meet the designation criteria.

4.3.2 ENVIRONMENTAL REGULATION AS A STIMULUS FOR ALTERNATIVE FUELS

Occasional attempts were made in the 1980s to require the use of clean alternative fuels to reduce pollutant emissions. These efforts eventually led to "fuel neutral" emissions standards that were challenging for gasoline and diesel engines. It is now believed that these standards will not force the use of alternative fuels (with one exception), although they present challenges for gasoline and diesel fuel.

The exception is that current California Air Resources Board (CARB) standards require that two percent of a manufacturer's sales in California must be "zero emission vehicles, or ZEVs" (electric vehicles) beginning in 1998. The fraction rises to ten percent by 2003. This provision has stimulated an intense effort by major manufacturers to develop commercially attractive electric vehicles that offer performance and costs similar to gasoline vehicles. California recently reaffirmed its ZEV requirement in the face of strong lobbying by major OEMs.

4.3.3 LOCAL PROGRAMS

Some states have adopted incentives promoting alternative fuels prominent locally, primarily ethanol and natural gas. They include excise tax exemptions, vehicle incentives, and sometimes fleet mandates keyed to specific fuels. These programs can be important in affecting local choices of alternative fuel technologies, and can effectively preclude gasoline and diesel fuel from competing in certain applications.

In Hawaii, incentives to promote alternative fuel use exist. For example, gasohol fuel is exempt from the state excise tax. There are also state deductions similar to EPACT for clean-fuel refueling facilities (Hawaii Revised Statutes, Chapter 235).

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[37] Those involved in the program include the City and County of Honolulu, HPTA, USDOE, USGSA, DBEDT, HNEI, PICHTR, HECO, BHP, and U.S. Electricar.

Table 4-7

Financial Incentives in National Energy Policy Act for Alternative Transportation Fuels

Description	Amount of Credit or Deduction
Income tax credit against the total cost of any electric vehicle	Maximum credit $4,000
Tax deduction for vehicles using methanol, ethanol, natural gas, or propane Gross vehicle weight:	Maximum amount of deduction[1,2]
<10,000 lbs	$2,000
Trucks/vans between 10,000 lbs and 26,000 lbs	$5,000
Truck/vans greater than 26,000 lbs and buses seating at least 20 passengers	$50,000
Tax reduction for alternative fuel storage (at the point of dispensing) and dispensing facilities (not including buildings)	Maximum amount deductible[3] $100,000
Tax credit for electricity produced from wind and "closed-loop" (dedicated) biomass	Amount of credit[4] 1.5 ¢/kWhr if sales price is 8 ¢ or less in 1992 terms; declines to zero at a sales price of 11¢

Source: National Energy Policy Act, 1992.

Notes:

1) Credits and deductions apply through 2001, then phase out at 25% per year for vehicles placed in service after 12/31/01.
2) Applies to entire vehicle cost for dedicated vehicles; applies to incremental costs for bi-fuel, dual-fuel, and flexible-fuel vehicles.
3) Expires 12/31/04; may be spread across several years.
4) For facilities placed in service between 12/31/93 (12/31/92 for closed-loop biomass) and 2/1/99, for a 10-year period of production.

4.4 THE DISPLACEMENT OF PETROLEUM THROUGH ALTERNATIVE FUEL USE IN THE GROUND TRANSPORTATION SECTOR

4.4.1 INTRODUCTION

The following analysis presents the resulting petroleum displacement of several possible scenarios. The focus of these substitution scenarios is the ground sector since significant substitution of aviation fuels is not expected during the period covered by this report.[38]

4.4.2 SCENARIOS

A "zero alternative fuels" projection is developed for comparative purposes. Then, a "baseline" scenario is considered, and variations are superimposed on the baseline. The baseline includes all requirements of EPACT and Executive Order (EO) 12844 (see Table 4-6); ethanol blending into gasoline at a statewide average rate of 7.5 percent; adjustment of state and county fuel taxes to reflect the lower energy content of alternative fuels; reduced rates for charging electric vehicles off-peak; and implementation of Administrative Directive 94-06. No state or county mandates for alternative fuels, incentives for the production of alternative fuels, or incentives for the purchase of alternative fuel vehicles are included in the baseline.

An "aggressive" scenario assumes, in addition to the baseline conditions, an increased rate of purchase of alternative fuel vehicles which could be driven by a combination of state mandates, incentives, or standards (individual measures, possible means of funding, effectiveness, and costs are discussed in additional detail in later chapters).

An "aggressive plus maximum gasohol and diesohol use" scenario assumes all of the conditions of the aggressive scenario, plus ethanol blending into gasoline at a statewide rate of 10% and ethanol blending into diesel at a statewide rate of 30%.

The default rate of vehicle population increase is the rate from Chapter 2. As described in Chapter 2, this study's reliance on existing transportation plans as the primary "driver" of future transportation energy demand is intentional, since it is not the purpose of this project or independently estimate future transportation activity. Development of a Hawaii-specific link between transportation and energy demand enables revisions of the energy demand projection whenever the underlying transportation projections are updated. However, to show the sensitivity of these estimates to a change in rate of vehicle population increase, a reduced

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[38] Although according to a Baylor University research team (Ninth International Symposium on Alcohol Fuels, Volume 2) certain cost and operational advantages may be realized with alternative fuel use in aircraft, the current low level of activity in this arena makes it difficult to propose any credible scenario which includes a significant penetration of alternative fuel use in aircraft.

rate is evaluated for both the "baseline" and "aggressive plus maximum gasohol and diesohol" scenarios.

In summary, the following scenarios are examined:

1. Baseline, with default rates of vehicle population increase;

2. Aggressive, with default rates of vehicle population increase;

3. Aggressive plus maximum gasohol and diesohol use, with default rates of vehicle population increase;

4. Baseline, with reduced rates of vehicle population increase; and

5. Aggressive plus maximum gasohol and diesohol, with reduced rates of vehicle population increase.

Evaluating scenarios such as these brackets a range of petroleum displacements that could occur. Assumptions may be altered and the results recalculated during the design of an implementation plan.

4.4.3 CAVEATS

The following caveats apply to the analysis:

EPACT schedules for AFV purchases may be changed or delayed in rulemaking.[39] The scenarios shown here assume full implementation of EPACT fleet purchase requirements.

Key limits to the aggressive scenario are the availability of alternative fuel vehicles (i.e. the manufacturers' willingness to provide alternative fuel capability as an option in their various car and truck lines)[40] and, most significantly, the rate at which available AFVs are purchased in Hawaii. Experience shows that this rate will be heavily influenced by:

- AFV technology, cost, and other elements affecting the relative attractiveness of AFVs to consumers;

- availability, accessibility, and cost of alternative fuels; and

- the level of public awareness and acceptance of AFVs as low-risk and/or socially-conscious investments.

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[39] Especially susceptible are the requirements for private and municipal fleets which do not begin until 1999 or, if rulemaking is delayed past 1996, until 2002. Further, start dates and roll-in percentages may be adjusted downward to account for constraints on fuel availability or on the availability of suitable vehicle models. If rulemaking is delayed past 1999, no requirements apply to these fleets.

[40] Those required in addition to national EPACT requirements.

4.4.4 THE BASELINE SCENARIO

In the baseline scenario (modeled for both default vehicle population increase and reduced rate of vehicle population increase) it is assumed that fleets on Oahu meet their AFV purchase requirements under EAPCT and EO 12844.

Only Oahu fleets are captured under EPACT because the requirements only apply to Metropolitan Statistical Areas with a population of 250,000 or more in 1980. In addition, except for non-tactical military vehicles leased from the federal GSA, military fleets on Hawaii are excluded because they are considered "deployable" and therefore not required to be AFVs (Lt. Col. Gavel, personal communication). Rental car fleets are also not included under EPACT requirements.

The default rate of vehicle population increase is the rate from Chapter 2. The reduced rate of vehicle population increase is roughly one-third the default rate.

4.4.5 THE "AGGRESSIVE" SCENARIO

In this scenario, it is assumed that state and other actions place AFVs in Hawaii beyond the requirements of EPACT and EO 12844. The "aggressive scenario" assumes that most fleets in Hawaii acquire AFVs. The differences between the aggressive scenario and the baseline scenario are the following:

- fleets not captured under the National Energy Policy Act, such as rental car or small fleets, are captured under a local program; and
- vehicle purchase incentives and fuel production incentives are included.

Variations in the retention in-state of resold rental vehicles are also modeled. In-state retention is understood to be small (less than 20 percent) and variable. More precise figures could not be obtained (Annalise McKean-Marcus, personal communication; Hardy Hutchison, personal communication). Cases treated in this analysis include the baseline amount of 10 percent retention, which we consider plausible and likely, 50 percent retention, which we consider to be a high case, and 100 percent retention, shown to illustrate the maximum conceivable introduction rate from rental fleets. The impact of rental fleet retention rates on the results of the "aggressive" scenario is shown in Table 4-8.

4.4.6 THE "AGGRESSIVE PLUS MAXIMUM GASOHOL AND DIESOHOL" SCENARIO

The effects of implementing maximum substitution strategies in conjunction with the aggressive scenario are also estimated. These strategies are:

- all remaining gasoline vehicles are fueled by gasohol, a blend of 10 percent ethanol and 90 percent gasoline; and

- all remaining diesel vehicles are fueled by diesohol, a blend of 30 percent ethanol and 70 percent diesel.

Another potential substitution strategy, the use of biodiesel (up to 20% vegetable oil or tallow-based esters blended with diesel fuel) was not explicitly modeled due to lack of information on the feasibility and costs of large-scale local production. This option may be revisited when additional information becomes available.

4.4.7 RESULTS AND CONCLUSIONS

Table 4-8 shows projected displacement of gasoline and diesel in the ground transportation sector. Results of the main scenarios are shown graphically in Figure 4-1. The baseline scenarios displace approximately nine percent of gasoline plus diesel use by the year 2014. The aggressive scenarios displace much more, especially with higher rates of retention of rental vehicles. For the expected case of ten percent retention, the aggressive scenario displaces about nineteen percent of gasoline and diesel use by the year 2014. If maximum blend strategies are included, the displacement in 2014 is estimated at about twenty-two percent of the total ground sector consumption.

Due to the slow roll-in of AFVs even in the aggressive scenario, gasoline demand grows to about the year 2000 before a decline begins, which gradually reduces gasoline use to the 1995 level by 2004. Thus, using the default rate of vehicle population increase, even the most aggressive measures are not expected to take gasoline volume away, but simply capture the expected growth in gasoline demand.

However, if the rate of vehicle population increase is significantly less than the default rate, both the "baseline" and the "aggressive plus maximum gasohol and diesohol" scenarios show a decline in demand for gasoline and diesel. This indicates the importance of transportation projections to energy demand forecasting and alternative fuel demand estimates.

4.5 THE DISPLACEMENT OF PETROLEUM THROUGH ALTERNATIVE FUEL USE IN THE MARINE SECTOR

Figure 4-2 shows the displacement of fuel used in the marine sector that would occur if all diesel was replaced with a 20 percent biodiesel blend. This analysis assumes that engines operating on residual oil would not use a biodiesel substitute, if only because residual oil is even less expensive than diesel, so that biodiesel-for-diesel substitution would occur first. These assumptions result in the displacement of about 700,000 barrels of diesel from the marine sector in 2014, with about 200,000 barrels of this displacement occurring in inter-island consumption.

Table 4-8

AFVs in Operation in Hawaii and Gasoline and Diesel Potentially Displaced

Scenario	AFVs in Operation by Year				Alternative Fuels: Total Demand in Millions of Gasoline Equivalent Gallons, by Year (and Percent of Total Ground Transportation Fuel Consumption)			
	1996	1999	2004	2014	1996	1999	2004	2014
Using default rate of vehicle population increase...								
BASELINE	205	993	14,036	56,989	**19** (4.8%)	**20** (4.9%)	**26** (6.2%)	**44** (9.6%)
AGGRESSIVE	662	8,477	44,395	167,019	**19** (4.9%)	**23** (5.9%)	**39** (9.5%)	**89** (19.3%)
AGGRESSIVE + 50% RENTAL CAR RETENTION	663	9,352	51,497	210,589	**19** (4.9%)	**24** (6.0%)	**42** (10.3%)	**106** (23.1%)
AGGRESSIVE + 100% RENTAL CAR RETENTION	663	10,445	60,376	265,057	**19** (4.9%)	**25** (6.1%)	**46** (11.3%)	**128** (27.8%)
AGGRESSIVE + MAXIMUM GASOHOL & DIESOHOL	662	8,477	44,395	167,019	**31** (7.9%)	**36** (8.9%)	**52** (12.6%)	**102** (22.2%)
Using reduced rate of vehicle population increase...								
BASELINE	205	930	12,422	45,762	**18** (4.8%)	**18** (4.9%)	**22** (6.2%)	**33** (9.2%)
AGGRESSIVE + MAXIMUM GASOHOL & DIESOHOL	640	7,898	39,511	133,413	**30** (7.9%)	**33** (8.9%)	**45** (12.4%)	**75** (21.1%)

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Figure 4-1

Statewide Gasoline and Diesel Fuel Consumption by Scenario

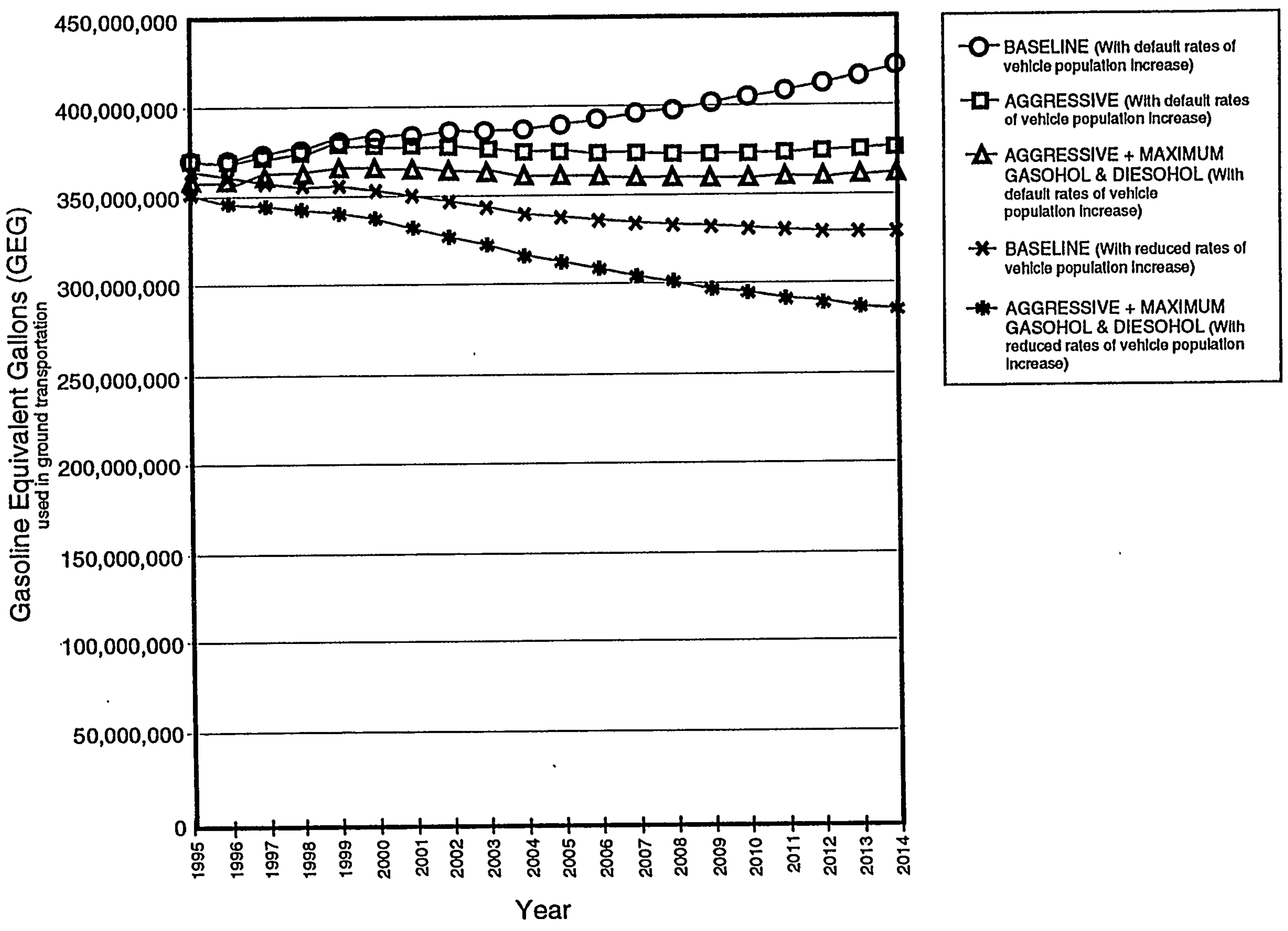
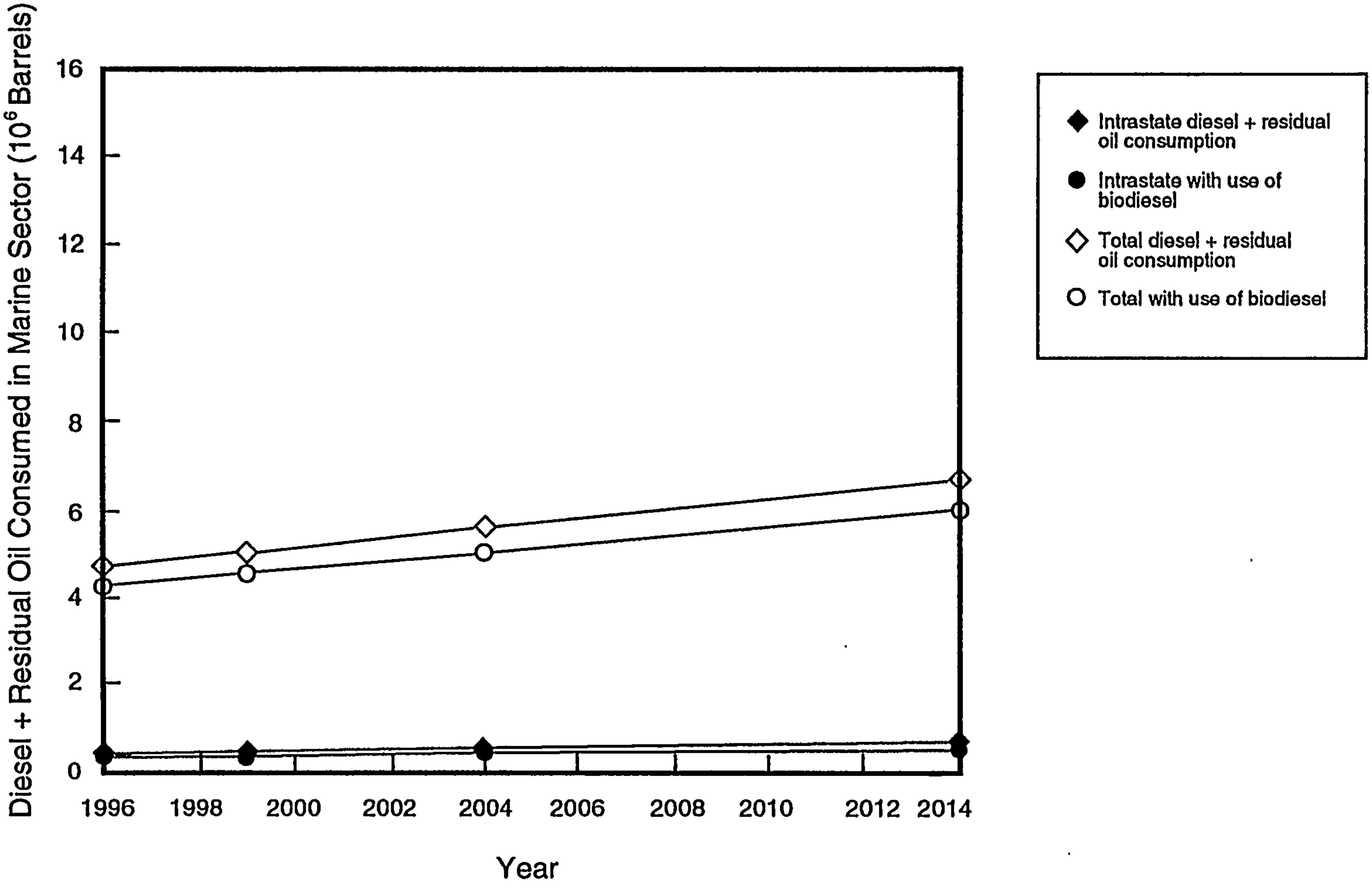


Figure 4-2

Replacement of Marine Diesel by Biodiesels



CHAPTER 5

A SCREENING OF ALTERNATIVE FUELS FOR POSSIBLE USE IN HAWAII'S GROUND TRANSPORTATION SECTOR

5.1 SCREENING CRITERIA

5.1.1 INTRODUCTION

This Chapter assesses fuel options for Hawaii in the context of state energy goals. It is important to note that in this analysis, the alternative fuels are not being compared with conventional fuels. The purpose of this screen is to compare the alternative fuels to each other to assess which appear, given what we know at this time, to best meet the state's energy objectives. Fuels that pass the screen are examined in more detail in this study.

5.1.2 DESCRIPTION OF THE SCREENING CRITERIA

In cooperation with the Department of Business, Economic Development and Tourism (DBEDT), criteria were developed for the various alternative fuel options[1] in order to assess their relative consistency with Hawaii's transportation energy goals. These criteria combine formal goals of the state with the understanding of DBEDT staff, based on the history of legislative, agency, and public efforts to define state energy goals. The criteria are now described.

Criterion 1. Offers energy security to Hawaii

A relatively large displacement of petroleum fuel, on the order of 40 percent, would afford some energy security to the State of Hawaii (Kaya, 1993). Alternative fuels provide some energy security through petroleum displacement, but the fuels may be further distinguished as either possible to produce from local resources or requiring importation.

Fuels that may be produced in substantial volumes from local resources at competitive prices (perhaps with government subsidy as justifiable based on economic benefits to the state) best satisfy this criterion. Local production at "competitive prices" implies that imports are not likely to capture substantial market share.

Non-petroleum imported fuels may provide increased supply security and price stability. Methanol, natural gas, and LPG (liquified petroleum gas) could be imported from either the mainland or from a number of other sources that may be more politically stable than the Middle East, which dominates oil markets. However, non-petroleum imported fuels rank lower under this criterion than fuels which may be produced from local resources.

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[1] References to "fuels" and "fuel options" also include technology options, such as electric and hybrid-electric vehicles.

Criterion 2. Offers environmental benefits (including safety)

Vehicles utilizing alcohols, biodiesels, electricity, hydrogen, natural gas, and LPG may be designed to achieve lower rates of pollutant emissions than vehicles fueled with gasoline or diesel. One of the primary reasons for manufacturers to market alternative fuel vehicles (AFV) is increasingly stringent air quality regulations. In designing, building, and operating low- or zero-emission AFVs, manufacturers are preparing to meet requirements for AFVs imposed by Federal, state, and municipal governments across the nation. AFVs have reduced (sometimes to zero) evaporative and tailpipe emissions compared to conventionally fueled vehicles.

Many alternative fuels offer other benefits as well. For example, spill hazards are greatly reduced or eliminated with many alternative fuels in comparison to gasoline and diesel. The safety codes that apply to alternative fuel production, distribution and on-board systems are generally more than sufficient to assure that public safety is no more threatened by any alternative fuel than by conventional fuels, when the fuels are handled in accordance with appropriate standards and practices.

Although comparing the relative environmental, health, and safety effects of each fuel option is a complicated task, in general, all of the alternative fuel options being discussed in this study have the potential to offer environmental, health, and safety benefits compared with gasoline and diesel fuel use (DeLuchi, 1989; Jones & Stokes Associates, Inc., 1993; Nowell, 1992; U.S. Department of Energy, 1991; U.S. Environmental Protection Agency, 1990).

Criterion 3. Potentially benefits Hawaii economy

Any fuel that may be produced locally from indigenous resources satisfies this criterion, insofar as the production requires local labor and expertise. Additionally, the potential for local employment in AFV-related businesses other than fuel production, such as vehicle manufacturing, conversion, or assembly, or battery recycling, must be considered when assessing economic benefits.

Criterion 4. Shows potential for locally available feedstocks to supply substantial volumes of energy

To qualify under this requirement, a fuel must show potential to be produced from local resources and be distributed to customers in sufficient volumes to meet large-scale demand. In addition, the vehicle technology associated with the use of the fuel must be appropriate for a significant portion of the transportation market.

Note that the long-term prospects for vehicle availability from original equipment manufacturers (OEMs) must be relatively strong for a fuel to satisfy this criterion. Alcohol, electric, natural gas (CNG and LNG (compressed natural gas and liquified natural gas)), and LPG vehicles are already commercially available. They are expected to be available in increasing numbers through the next few decades as manufacturers respond to the legislative and regulatory drivers discussed in Chapter 4. Biodiesel use does not require OEM participation, as it could be used in virtually unmodified diesel vehicles. Hydrogen vehicles are the furthest from commercial availability, but large research efforts are addressing both fuel cell and hydrogen internal combustion engine technology (Veziroglu and Barbir, 1992;

U.S. Department of Energy, 1993), so we assume that hydrogen vehicles will eventually be available. Therefore, vehicle availability prospects are good for all of the alternative fuels discussed here.

Criterion 5. Likely to be increasingly competitive with gasoline and diesel

Fuels which are expected to become increasingly competitive with gasoline and diesel are those whose real prices are expected to decline due to technological progress in their production. Fuels whose prices are more closely coupled to oil prices, such as synthetic natural gas (SNG) and LPG, rate lower than fuels which are less linked to oil prices.

Criterion 6. Provides flexibility and less uncertainty

A program to encourage alternative fuels will need some redirection as the program proceeds because of technological innovations and market forces. The program must therefore have flexibility. For example, it would be preferable to avoid requiring a large number of vehicles which could only be operated on a single alternative fuel ("dedicated" vehicles). If experience shows that the production and delivery of that fuel is economically nonviable, those vehicles would have to be converted, abandoned, or operated at great expense. As another example, it would be inadvisable to construct an alternative fuel production facility only to have the market for that fuel be short-lived, or even fail to materialize, should another fuel become preferable, or should vehicles for that fuel no longer be available.

To best meet this criterion, AFVs should be fuel-flexible. Examples include electric vehicles, since electricity is producable from many fuels, and methanol or ethanol fuel-flexible vehicles (FFVs). Converted LPG and natural gas vehicles that could be reconverted to petroleum fuels offer a lesser degree of flexibility.

Another factor under this criterion is that the market for the locally produced fuel should be relatively secure.

Criterion 7. Currently locally available in enough volume to supply demonstration programs

Any fuel which could be purchased currently from a local entity satisfies this criterion.

Criterion 8. Could be used in vehicles which are currently commercially available

Fuels for which AFVs are commercially available from major manufacturers rate highest under this criterion. Fuels for which AFVs are available as conversions or from small producers rate next highest, and fuels for which virtually no vehicles are commercially available rate lowest.

Criterion 9. Could be used to some degree immediately and with little effort and cost

Any fuel and technology combination which could be deployed soon, for which the vehicle technology is available and acceptable to the user, and for which the fuel could be made available at a reasonable price with minimum public subsidy, qualifies under this criterion.

Criterion 10. Has broad public support

The degree to which the public has demonstrated interest, enthusiasm, and support for any particular fuel is important, especially since public funds would be required to provide financial support for any alternative fuel program that aims at more than token market share. The relative degree of public support for each of the fuel options has been estimated by DBEDT in this study.

5.2 SCREENING ANALYSIS

To evaluate the fuel options which best satisfy Hawaii's energy goals as embodied in the criteria, the criteria were separated into two categories: "long-term strategic considerations" and "near-term considerations." Criteria 1 through 6 are "strategic," while criteria 7 through 10 are "near-term." The strategic criteria indicate which fuels are likely to be most beneficial to the state in the long run, while near-term considerations identify those options more easily implemented soon.

The screening analysis results are summarized in Table 5-1. The scope of this project did not allow supporting each rating with a detailed study. Qualitative ratings were based on current understanding. What follows is a discussion of the scoring of each fuel option.

5.2.1 ALCOHOLS: METHANOL AND ETHANOL

Discussion

Alcohol fuels may be produced locally both from biomass (such as sugar cane, banagrass, or tree crops) and waste products, such as green waste and municipal waste. Ethanol has already been produced from molasses in the state, and new efforts to produce ethanol from biomass and waste products are currently being undertaken by the Pacific International Center for High Technology Research (PICHTR), Arkenol, Cargill, Amoco, and others. DBEDT, the Hawaii Natural Energy Institute, and PICHTR have a number of programs underway to demonstrate methanol production from biomass. Some of the candidate conversion technologies are currently available, while others require more development (see Chapter 4).

Local production of fuel in sufficiently large volumes would provide a measure of energy security, insulating the Hawaii economy from disruptions in oil supply or price shocks. Additionally, use of methanol and ethanol produced locally has the potential to benefit the Hawaii economy, even if a state subsidy is required to make the price of alcohol at the pump competitive with that of gasoline or diesel. Energy crops could save agricultural jobs and create jobs in new industries. Hawaii's capacity to produce alcohol fuel is substantial. Chapter 7 further discusses indigenous biomass energy sources.

Table 5-1

Screening Analysis Results

Criteria Categories	Criteria	Alcohol	Biodiesel	Electricity	Hydrogen	NG	SNG	Propane/LPG
Long-Term Strategic Considerations	1. Potentially offers energy security to Hawaii[1]	+	+	+	+	0	-	0
	2. Potentially offers environmental benefits (including safety)	+	+	+	+	+	+	0
	3. Potentially benefits Hawaii economy	+	+	+	+	-	-	-
	4. Shows potential for locally available feedstocks to supply substantial volumes of energy	+	?[2]	+	+	-	-	-
	5. Likely to be increasingly competitive with gasoline and diesel	+	+	+	+	0	0	0
	6. Provides flexibility and less uncertainty	+	+	+	0	-	-	-
Near-Term Considerations	7. Currently available in enough volume to supply demonstration programs	+	-	+	-	-	+	+
	8. Could be used in vehicles which are currently commercially available	+	+	+	-[3]	+	-	+
	9. Could be used to some degree immediately and with little effort and cost .	0	0	0	-	-	-	+
	10. Has broad public support[6]	+	+	+	0	0	0	+
Pass the Screen?		**Yes**	**Yes**	**Yes**	**No[4]**	**No**	**No**	**Yes[5]**

Notes:

1) A "+" score indicates that a fuel has a reasonable potential to be produced in substantial volumes from domestic resources. A "0" score implies that an imported fuel might offer increased security of supply and price stability compared with crude oil imports.
2) No analysis available on potential biodiesel production on Hawaii: Crop dependent, among other factors.
3) In this study, 'hydrogen vehicles' are considered to be internal combustion engine vehicles.
4) Although hydrogen scores well with respect to the strategic criteria, its score under near-term considerations is prohibitively poor and it will only be considered briefly in the remainder of this study.
5) Although propane scores poorly with respect to the strategic criteria, its score is clearly superior for near-term considerations and it will, therefore, be considered further in this study.
6) DBEDT estimate.

Imports are not expected to capture ethanol market share because adding the cost of transporting ethanol to the state is expected to render imported ethanol non-competitive. (Cost analyses in Chapter 8 support this conclusion.) Methanol, on the other hand, is typically produced outside of Hawaii from natural gas, at a substantially lower cost than methanol produced from fiber.

Utilization of local production capacity depends upon vehicle availability. Alcohol vehicles are already commercially available and the technology is more mature than that of any other alternative fuel vehicle except possibly LPG. The prospects for alcohol AFV availability into the future are not certain, but it is expected that vehicles would be available in increasing numbers in response to Energy Policy Act (EPACT) requirements, aggressive California programs, and other regulatory actions as discussed in Chapter 4.

Although costs are not currently competitive, alcohols are expected to be more competitive in the future due to technology improvements and increases in scale of use (affecting both production and distribution costs), coupled with increasing gasoline and diesel prices as environmental regulations, increasing regional and worldwide demand, and eventual increases in production costs drive up prices. Because the production costs of alcohol from biomass are more likely to fall than rise, we consider that alcohol from biomass is likely to be increasingly competitive with gasoline and diesel over the long-term.

Finally in terms of the strategic criteria, an alcohol strategy would be relatively low risk and flexible. This is because:

1) Light-duty alcohol vehicles are commercially available as FFVs.

   All of the light-duty alcohol vehicles being sold today are FFVs. They could operate on any combination of alcohol and gasoline from 100 percent gasoline to 85 percent alcohol. In the event that alcohol were not available, FFVs could be fueled on gasoline throughout the vehicle lifetime. Heavy-duty alcohol vehicles are typically dedicated, meaning that they must be fueled with the alcohol blend. Therefore, alcohol substitution in heavy-duty fleets is less flexible than alcohol use in light-duty fleets.

   An important complication is that commercially available vehicles tuned to one alcohol (say, methanol) cannot operate on the other (say, ethanol) without some adjustments to reset the engine timing and other parameters. Conversion of vehicles from one alcohol to the other has been discussed in Chapter 4.

2) A low-level alcohol blend strategy (e.g., gasohol) could be employed to balance alcohol supply and demand.

   In general, alcohol supply and distribution may be designed to flexibly meet increasing demand. In the case of overproduction, low-level gasoline/alcohol blends could be employed to create a market for alcohol produced in Hawaii. In the case of under-production, methanol imported from the west coast could be used before a local supply is available, and could also be used to supplement local supply to allow time for increasing production and distribution capacity in the state. Alternatively, FFVs could fuel with gasoline for a number of years until locally produced methanol becomes available.

Local production of ethanol could come on-line much faster than methanol. Ethanol plants may be built economically on a fairly small scale and have already been operated in the state, although none is currently in operation.

There is no reason that fuel distribution, which will be outlined in Chapter 6, should not keep up with fuel supply.

3) Biomass grown for alcohol production could be converted into electricity.

   Should biomass be grown in Hawaii for production of alcohols, and should electricity replace alcohol as the alternative transportation energy of choice, locally produced biomass would still have a market because it could be converted into electricity.

4) Alcohol is a front-runner candidate fuel for on-board fuel-cell (electric) vehicles.

   Methanol is one of the most practical hydrogen sources for use with fuel cells (DeLuchi et. al., 1991), which, some believe, are the best energy storage device for EVs. The methanol molecule (CH_3OH) is an efficient hydrogen carrier that may be delivered to and stored on-board a vehicle more easily than compressed hydrogen. Although the technological future of fuel cell vehicles is impossible to predict, should fuel cells become a viable and cost-effective means to power vehicles, local methanol production capability could be diverted from use in internal combustion (IC) vehicle engines to fuel cells.

In addition to satisfying the strategic criteria, the alcohol fuels score fairly well with respect to the near-term criteria. Alcohol-fueled AFVs built by major manufacturers could be deployed immediately, at no incremental cost for some vehicle types when compared to dedicated gasoline versions.[2] The use of alcohol as a motor fuel appears to have public attention and support. Alcohol fuel is currently available in the state and is being used in General Services Administration (GSA) and University of Hawaii (UH) vehicles on Oahu and Maui. Ethanol could be produced in the state in the near-term, perhaps within two to five years.

Conclusion

Methanol and ethanol satisfy all of the strategic criteria as well as some of the near-term criteria, and are thus evaluated further in this study.

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[2] FFV passenger cars are being sold in California at prices equal to or less than their gasoline counterparts. Although the FFVs, manufactured in small volumes, cost more to produce than conventional vehicles, the manufacturers price them competitively, indicating a vested interest in keeping the alcohol program alive. Alcohol vehicle sales give the manufacturers compliance options under the California LEV program, EPACT fleet market share, and a CAFE standards compliance margin. Alcohol-fueled transit buses are currently more expensive (by about 20 percent) than diesel buses.

5.2.2 BIODIESELS

Discussion

Biodiesel could be made in the state from local feedstocks, including waste oil from the fast food industry, waste from meat processing, and suitable oil crops. Currently, no biodiesel production exists in Hawaii.

The use of biodiesel blends as a substitute for petroleum-based diesel fuel could provide Hawaii with energy security in the heavy duty transportation sector. Because biodiesel blends could be used with minor modifications to engines,[3] biodiesel could power Hawaii's heavy duty buses and trucks, off-road equipment, and diesel-fueled marine vessels. Furthermore, because biodiesels are so similar to regular diesel, existing infrastructure could be used for their distribution and marketing (with the exception of requiring biodiesel-compatible materials for seals and hoses). Biodiesels might also be useful as fuel additives; the transesterified oils could potentially be used as additives to alcohol fuels to raise cetane levels (improving ignition) and to provide lubrication (alcohol lubricity is very low compared with gasoline and diesel fuel).

The features described above give biodiesel a very significant capital cost and implementation advantage over other alternative fuels. However, biodiesels are expensive to manufacture because fuel and feedstock costs can be high. Interchem Industries, Inc., which is very active in developing biodiesel for use in the U.S., has worked with Procter & Gamble to produce soy diesel in a full scale plant in Kansas City, Kansas. This plant could produce up to 25 million gallons of soy diesel per year. The current price (which depends on the volume purchased and the current price of soybeans) is about $2.50 to $2.60 per gallon (100 percent soy diesel, i.e., neat fuel) (Ayers, 1993).

If biodiesels could be produced locally at competitive prices, they would provide a measure of energy security while benefiting the Hawaii economy. Locally produced oils are now being produced for higher-priced markets, such as the food and cosmetic industry.

Hawaii's ability to produce oils in large volumes from oil seed crops is uncertain. The Hawaii Natural Energy Institute (HNEI) has never considered locally produced oil to be a mainstay fuel source. On a per acre per year basis, the energy contained in reported oil yields from oil crops (Reed, 1993) appears to represent only about 25 percent as much energy as is assumed for sugar or fiber crops, although relative productivities for similar locations in Hawaii are unknown.[4] Some oil crops may have the advantage of requiring minimal care, and some crops could, perhaps, be grown on marginal land. Local studies would be needed to ascertain the cost effectiveness of growing oil crops for fuel in specific volumes and areas. Until and unless such cost effectiveness is shown, there is little reason for Hawaii to import biodiesels except, perhaps, for demonstration purposes. Imported biodiesels, even used in 20 percent blends, would be quite expensive compared with regular diesel, and as biodiesel blends could be distributed through the current diesel distribution and marketing system and

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[3] Biodiesel can erode rubber, so rubber fuel lines or seals must be changed.

[4] The total plant energy content per acre actually includes (in addition to energy contained in the oils) energy contained in leaves, stalks, stems, etc.

used with minor modifications to engines,[5] there would be no need to import the fuel to support the development of new infrastructure or markets.

The costs of biodiesel would vary substantially depending on the feedstock, and would require careful study. Biodiesel from the major oil crops currently grown in the state, such as macadamia or kukui nuts, would be exceedingly expensive since these oils would otherwise be used in high-value, non-fuel markets. For example, the wholesale price of macadamia nut oil is about 15 to 18 dollars per gallon (Hawaii Kukui Nut Company, 1993). Transesterification to convert the oil to biodiesel would further increase the per gallon cost of this fuel. Biodiesel from soybeans, peanuts, sunflowers,[6] or other oil seeds might be manufactured in Hawaii at costs similar to those on the mainland, provided the meal fraction could be sold to the feed industry (Ayers, 1993).

The least expensive option would be to manufacture biodiesel from waste oil, such as the cooking oil discarded by fast food restaurants. This oil is currently sold for 12 cents per pound and shipped to Los Angeles, California for use in the feed industry (Ayers, 1993). Biodiesel production from waste oil in Hawaii could reach 500,000 to 700,000 gallons per year (Ayers, 1993). This volume would support a 20 percent blend in 150 to 200 transit buses, and would replace less than 1 percent of the diesel fuel currently used in the ground transportation sector and less than 0.5 percent of the total diesel fuel consumed in the state.

The Mason Research Foundation sees potential in Hawaii for oil production from the Chinese tallow tree. This tree produces seeds which consist of a thin, hard shell coated with a waxy fat, which contains an oil similar to tung oil. Oil yield per acre is high, about 12 barrels per acre per year, and after the oil has been extracted, the meal (comprised of the leftover shell and fatty coating) could be used as animal feed or fertilizer. The Chinese tallow tree, which typically reaches maturity in five years, has been found to be very hardy and could produce seeds in poor, waterlogged, and even salty soil. This tree has been identified by the U.S. Department of Agriculture (USDA) as a possible "industrial crop," and the Foundation has been studying the tree since the late 1970's. Studies have occurred in Hawaii for a number of years, partly with state support. The Chinese tallow tree has grown well in those locations in the state where it has been tested. However, the primary barrier to bringing Chinese tallow tree oil to market is the intense labor required for harvesting. The seeds will not fall off with shaking. Instead, each set of seeds must be individually clipped from the tree and the twigs manually separated from the seeds. The Foundation has been working to achieve a more economical method of harvesting. The Foundation has not yet evaluated the costs of fuel oil from the Chinese tallow tree, but expects that the oil would be sold as a food oil, where a higher price could be obtained, rather than as fuel (Boom, 1993).

To address the remaining strategic criteria, biodiesel is clearly flexible since it could be used in conventional vehicles. Therefore no risk exists of stranding vehicles without fuel, or investing in fuel production capacity without a market to serve. Biodiesel is also expected to become more competitive with diesel in the long run if oil prices rise and if the cost of producing crops could be decoupled from the price of petroleum fuels.

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[5] Again, material compatibility issues for fuel lines and seals may require some modification of the existing infrastructure and on-board fuel delivery systems.

[6] The per acre yield of sunflowers is about twice that of soybeans (Ayers, 1993).

The near-term criteria are partially satisfied by biodiesel. Vehicle availability presents no obstacle for this alternative fuel, and, were the fuel to be made available, it could be used in vehicles immediately with relatively low cost and effort.

Conclusion

Locally produced oils appear to satisfy the strategic criteria fairly well, although further work, outside the scope of this study, would be required to estimate how much biodiesel Hawaii might produce and at what costs. The role of locally produced biodiesel is not considered in detail in this study.

Imported biodiesels do not meet the strategic criteria of providing energy security (being produced from local resources) or benefiting the economy of Hawaii. Furthermore, unlike imported alcohol fuels (which might be needed to build up a population of alcohol-compatible vehicles and special infrastructure, thus facilitating the later distribution and use of locally produced alcohol fuel), imported biodiesel is not needed initially because special vehicles and infrastructure are not required for its use. However, imported biodiesel could be used to fuel a demonstration program and stimulate local interest and confidence. Such a demonstration could be a vital step toward achieving a business climate where industry might invest in biodiesel production in Hawaii.

5.2.3 ELECTRICITY

Discussion

Electricity is the most flexible power source for motor vehicles since it decouples vehicles from the original fuel. Electricity may be produced from many renewable resources, including wind, solar, geothermal, and biomass. In 1993, about 74 percent of Hawaii's electricity was generated by petroleum. The remainder came from biomass,[7] hydropower, wind, coal, and solar power (DBEDT, 1994). The current use of renewables varies by island. All of Lanai's generation is from petroleum, while almost 23 percent of Kauai's electricity is generated from renewable sources (DBEDT, 1994). On Oahu, petroleum generation represented about 74 percent of the mix. The use of coal for power generation on Oahu is increasing dramatically. For electric vehicle (EV) use to be most consistent with a goal of energy security and increased energy self-sufficiency, electricity production from domestically available renewables would need to increase. However, electricity produced from coal, which may offer increased security of supply and price stability compared to oil, would contribute to Hawaii's energy security goals as well.

Increased, cost-effective production of electrical energy from local renewable resources, rather than from imported oil or coal, would benefit the Hawaii economy. EVs could stimulate the local economy in other ways as well. EV conversions could be performed in the state to a greater degree than they are already and, potentially, EV assembly, component manufacture,

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[7] Biomass-to-electricity conversion has occurred in Hawaii for years. For example, bagasse is used as a boiler fuel at sugar mills to provide process steam and electric power. Excess power is sold to the local electric company.

or ground-up vehicle manufacture could develop more in Hawaii.[8] Hawaii has a strong history of EV interest and development, and is one of five regions in the country to receive grants from the Advanced Research Projects Agency in 1993.[9] Infrastructure development and battery handling and/or recycling would create jobs, as well.

The quantity of electric power available would not hinder any EV programs in the near-term. On Oahu, due to purchase commitments with independent power producers, Hawaiian Electric Company (HECO) has nighttime operational problems resulting from low demand, and would benefit from the load-leveling that could occur with nighttime EV charging (Mulki and Waller, 1992). EVs could, therefore, increase operational efficiency of the utilities and provide benefits to rate payers. HECO has been actively supporting EV development in Hawaii. HECO and others in the state with an interest in EV development must resolve many institutional, financial, regulatory and other issues before there could be major adoption of EVs, however. It is beyond the scope of this analysis to resolve the many barriers facing deployment of EVs in Hawaii. Based on the current level of efforts being focused on EVs, and the substantial legislative and regulatory impetus for EV development, it seems safe to assume that EVs will be available in increasing numbers and with increasing consumer acceptance into the future.

EVs are commercially available, however, EVs are currently very costly compared with conventional vehicles (Terpstra, 1993). Current technological and other limitations (range and performance reduction, recharging procedures, batteries) constrain the market appeal of EVs to niches where limitations and inconveniences are acceptable, such as local shuttle buses and delivery vehicles. If research and development efforts are successful, the many other barriers facing EV deployment are addressed, and sale volumes increase, future EVs would be more cost-competitive with gasoline and diesel technologies, and would be an acceptable choice across a wider range of applications[10] than at present. The potential clearly exists for EVs to achieve substantial penetration in the long term and to contribute toward Hawaii's energy security.

EVs satisfy the near-term considerations in that they have public support,[11] electric power is available, and some vehicles are available. However, because EVs are currently very costly

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[8] Hawaii already has one organization that is marketing EVs, the Suntera Solar Chariot Company located in Hamakua on the island of Hawaii. An EV industry centered in Hamakua could provide alternative employment for those in the sugar industry. Suntera was recently awarded a loan from DBEDT in advance of receiving additional funds through the Hawaii Electric Vehicle Demonstration Project funded by the Advanced Research Projects Agency (see the following footnote).

[9] The Hawaii Electric Vehicle Demonstration Project (HEVDP), supported by a 24-month, $5 million grant from the Advanced Research Projects Agency (ARPA), as well as by private-sector support of about $6 million, will include 37 electric vehicles, including 3 buses, and manufacture of a commuter car, the Suntera SUNRAY, on the Big Island. The HEVDP will also include infrastructure development and data acquisition.
The current grant is expected to be the first in a series. Many view the potential multi-year funding for electric vehicles by ARPA to be an excellent opportunity to establish a "critical mass" of EV interest, technology, expertise, experience and infrastructure in the state.

[10] Possible applications for EVs in Hawaii are numerous, and take advantage of Hawaii's unique island setting, creating short average trip lengths in comparison to the mainland. Just a few possible applications that have been mentioned include:
- residentially based short-trip errand cars;
- home-work commuter vehicles;
- hotel-based rental vehicles for tourists;
- tour vehicles for parklands; and
- airport-hotel shuttles.

[11] Manifestations of support for EVs in Hawaii are numerous, and include:
- the hosting of the EV '93 Conference in Honolulu, which included technical and public programs and the "Pali Challenge," a demonstration of EVs over a 35-mile course that included the Pali.

(Terpstra, 1993) and the technology is still developing,[12] near-term implementation may be more challenging in these areas for EVs than for other alternative fuel options.

The recent experience of California with respect to EVs should be noted. EVs, as Zero Emission Vehicles (ZEVs), satisfy California's ZEV purchase requirement. However, domestic vehicle manufacturers continue to lobby to weaken this purchase requirement.

Conclusions

EVs satisfy all of the strategic criteria, some of the near-term criteria, and will be evaluated further in this analysis.

5.2.4 HYDROGEN

Discussion

Although hydrogen is primarily produced from fossil fuels such as coal and natural gas, hydrogen may be produced from renewable resources by water electrolysis.[13] Several other processes are being investigated internationally (Veziroglu and Barbir, 1992). Not yet commercially ready, but technically feasible, is hydrogen production from biomass gasification. Several pilot-scale systems have been demonstrated, and an important study performed by HNEI and the Florida Solar Energy Center found biomass gasification to be the most economical way to convert renewable resources into hydrogen (DeLuchi, et. al., 1991).

As with any alternative fuel which could be produced from locally available resources, hydrogen has the potential to provide energy security and economic benefits to the state.

The total amount of hydrogen energy which could be produced in the state has not been estimated as part of this study. With electrolysis, hydrogen production capacity is only limited by the supply of water and inexpensive electric power. Note that in a "renewable hydrogen" scenario, the supply of electricity from renewable resources is the limiting factor. Given the abundant salt water and renewable resources of Hawaii, we assume that a substantial percentage of the state's transportation energy demand could be met with hydrogen, and defer a quantitative evaluation to future studies.

The other aspect of whether an alternative fuel could supply a large portion of Hawaii's transportation energy is vehicle availability and distribution infrastructure. Hydrogen may be

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- frequent testimony in support of EVs at public forums on energy, which is often combined with comments on the types of lifestyles and land use patterns that could be associated with large-scale EV use;
- active, politically aware and well-informed advocacy groups, and
- articles on EVs in HECO's monthly newsletter to its customers.

[12] Just how EV technology and other issues affecting the implementation of EVs are developing was made apparent at the EV '93 Conference in Honolulu. Presentations were made by component manufacturers, vehicle assemblers and manufacturers, government agencies, coordinators of the five EV projects being funded by ARPA, land use planners, electric utilities and many others. It is clear that EVs face many technical, institutional, legal, regulatory and financial challenges. However, it is also clear that the EV field is highly dynamic, making estimates of the state of resolution of the many barriers facing the broad implementation of EVs highly uncertain.

[13] In order for hydrogen from electrolysis to be considered renewable, the electricity must be generated from a renewable source: biomass, solar, wind, OTEC, or others.

used to fuel internal combustion engine (ICE) vehicles or fuel cell vehicles. In this study we consider only ICE hydrogen vehicles which are thought to be closer to commercialization than fuel cell vehicles (McKinley, 1993).

Of all the alternative fuels discussed in this study, hydrogen is the farthest from commercialization as a motor vehicle fuel. While hydrogen use in motor vehicles is impeded by the same factors that affect the other alternative fuels (lack of infrastructure, immature vehicle technology, and, more importantly, economic disadvantages), the most apparent reason for hydrogen vehicle commercialization lagging behind other alternative fuel technologies is the relative difficulty of storing hydrogen.[14] Storage of hydrogen, particularly on-board, poses unique technical challenges.

Hydrogen could be stored as a compressed gas, a cryogenic liquid, or as a gas bound to metal hydrides or absorbed on activated carbon. All of these technologies are expensive on-board a vehicle, and to obtain ranges similar to conventional vehicles, would require larger storage volumes due to the physical properties of hydrogen (DeLuchi, 1989). For example, although a pound of hydrogen contains over twice the energy of a pound of natural gas, the density of hydrogen is almost one-eighth the density of natural gas under standard conditions. Therefore, it is more difficult to store energy on board a vehicle as hydrogen compared to natural gas. To store adequate amounts of fuel on a vehicle, compressed gaseous hydrogen would theoretically need to be stored at 10,000 psi (DeLuchi, 1989), roughly three times the typical pressure used for natural gas storage in vehicles. Alternatively, as a cryogenic liquid, hydrogen must be stored at about -425°F, compared with liquefied natural gas temperatures of about -238°F. Such low temperatures require super-insulated, bulky storage vessels. While technologically feasible, hydrogen storage on-board presents significant economic and practical disadvantages.

For the reasons outlined above, hydrogen vehicles are seriously handicapped with respect to near-term implementation. At this time, only a very limited number of vehicles have been modified to run on hydrogen, serious storage problems remain to be solved, and the costs associated with hydrogen vehicle operation are very high.

While costs are currently very high for hydrogen production (especially from renewable resources), distribution, storage, and vehicle operation, technological improvements are expected to bring the costs down significantly over the next few decades (DeLuchi, 1989; DeLuchi et. al., 1991; Veziroglu and Barbir, 1992), and we assume that hydrogen vehicles would be increasingly competitive with conventionally fueled vehicles.

Finally, the flexibility of a hydrogen program is unclear at this time. Hydrogen engines appear to have the potential to be fuel-flexible (DeLuchi, 1989), a feature which would greatly increase the flexibility of a hydrogen strategy. Hydrogen could be used in vehicles or in stationary fuel cell power plants as these become competitive. Provisionally, the flexibility of a hydrogen program appears to fall between the flexibility of an alcohol program and the less-flexible natural gas option.

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[14] Engine technology does not present a substantial obstacle. Gasoline engines have been successfully modified to run on hydrogen and have achieved thermal efficiencies 15 to 50 percent greater than gasoline operation. The best performance has been found using direct injection of liquid hydrogen (DeLuchi, 1989). Hydrogen vehicles have been developed in limited numbers for research and as prototypes by Daimler-Benz and BMW (North, 1992).

Conclusions

Hydrogen rates well with respect to the strategic criteria. This fuel could potentially be produced in Hawaii in large volumes from local resources and used to fuel motor vehicles, offering the state energy security and economic and environmental benefits. The fuel is likely to be increasingly competitive with gasoline and diesel, although the time frame for this competitiveness is unclear. A hydrogen program would probably be somewhat flexible, as the fuel may be used in ICE or fuel cell vehicles, and ICE vehicles could possibly be FFVs.

However, hydrogen motor vehicles are far from being commercially ready. Advances and cost reductions are needed in hydrogen production from renewables, storage and distribution, and vehicle applications, before it could be considered a real option in the alternative fuels arena. It is premature to consider hydrogen infrastructure, policies and costs in detail in this study.

5.2.5 NATURAL GAS AND SYNTHETIC NATURAL GAS

Discussion

Natural gas is a popular alternative fuel on the mainland because of the availability of inexpensive gas from wells, combined with the efficient, existing pipeline distribution network. The costs of natural gas infrastructure have been distributed over the entire rate-base of over 55 million residential, commercial, and industrial users (American Gas Association, 1992). These advantages result in the price of uncompressed gas to the refueling station being less than one half of typical wholesale gasoline prices on an energy equivalent basis.[15] This low energy cost in part offsets the high capital costs of compressor stations or liquefaction facilities, natural gas vehicles, and the cost of the energy required to compress or liquefy the gas. Currently, on the mainland, natural gas and methanol are the prime competitors for the EPACT market. The economics of alcohol on the mainland are characterized by higher fuel costs than both natural gas and gasoline on an energy equivalent basis, and lower capital costs than natural gas.

In Hawaii, however, natural gas has significant disadvantages. First, Hawaii has no natural gas reserves or importation infrastructure (see Chapter 4's discussion of synthetic natural gas). Because of this, natural gas in Hawaii would be considerably more expensive than natural gas on the mainland.[16] The natural gas used in Hawaii currently is SNG, a product of oil refining. Natural gas vehicles would not run on SNG, so natural gas produced locally from biomass or waste feedstocks (as was described in Chapter 4), or natural gas imported as a cryogenic liquid (LNG) would need to be provided for vehicles.

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[15] Estimate based on uncompressed natural gas at 30 cents per therm, a typical price a transit district (at a non-core rate) would currently pay in California. Wholesale gasoline prices of about 70 cents per gallon are consistent with 1991 and 1992 California prices.

[16] The total production capacity of the existing SNG plant is 150,000 therms (HHV) per day, about 5 percent of the energy used for ground transportation in 1990. SNG is currently priced at 62 cents per therm, about twice as much as natural gas used for transportation on the mainland. This price may be more of a function of the price of competing fuels than of cost. The cost of SNG production was not researched as part of this study.

Imported LNG, if necessary, could supply large volumes of fuel, but at a high cost[17] and with less energy security and economic benefits compared to a fuel produced from local resources, especially if LNG was not produced in the United States. Imported natural gas would carry the cost of shipping, which would be very high for the small volumes Hawaii would import to support an early vehicle program. Without low-priced gas to offset high capital costs for distribution facilities, compressors, refueling equipment and vehicles, operators of natural gas vehicles in Hawaii would bear a very high cost burden.

The potential capacity for local production of natural gas from waste is small.[18] Methane could be produced by biomass gasification in larger quantities; however, given similar production costs, alcohols would be preferable to methane because liquids are easier (and cheaper) to distribute and store than gases.

Natural gas vehicles do not provide the flexibility of the alcohol vehicles. They are typically dedicated, rather than fuel-flexible, to achieve adequate fuel economy and range, and therefore could not be operated on another fuel if natural gas were in short supply.

For the near-term, natural gas rates well in terms of vehicle and fuel availability. However, it does not rate well in implementability with little effort and cost, because the cost of the fuel in Hawaii would be high, it is costly to compress gas and transfer it on to a vehicle, and vehicles themselves are costly.

Conclusions

Natural gas does not satisfy the strategic criteria. Even if technological advances reduce the cost of production from renewables, waste would not supply enough fuel to meet a large demand, and biomass-derived natural gas is unlikely to be competitive with biomass-derived alcohols once infrastructure and vehicle costs are included. Imported gas does not compare well with fuels produced from local feedstocks under the strategic criteria. It is not feasible to use SNG in vehicles. For these reasons, we do not conduct a detailed assessment of natural gas in this study.

5.2.6 LIQUEFIED PETROLEUM GAS (LPG/PROPANE)

Discussion

Liquefied petroleum gas, also commonly known as LPG or propane, (see description of fuel in Chapter 4) is currently in favor as an alternative fuel on the mainland for several reasons. The fuel is typically less expensive than gasoline because it is available in increasing amounts due to an expanding natural gas industry (propane is extracted during natural gas processing and oil refining). Requirements for reduced gasoline volatility in several areas on the mainland, also require increased butane removal. (Butane may be added to LPG in small amounts

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[17] The Hawaii Energy Strategy Project 2: Fossil Energy Review and Assessment (1993) estimated the costs of an entire LNG production, transportation, and terminal system at $3.2 billion.

[18] The report Methane Resource Assessment for Hawaii, (Department of Planning and Economic Development, 1984), concludes that a maximum of 3.415 billion Btu or 28,496 gallons gasoline equivalent per day could be provided with methane produced from animal wastes, landfills, and wastewater treatment plants. This translates into a 2 percent reduction in 1992 ground sector fuel use.

without violating the commercial specification). Also (see discussion in Chapter 4), LPG is a familiar fuel which has been used in forklifts and utility vehicles for many years.

Hawaii currently consumes about 30 million gallons of LPG per year, most produced by local refining, but some imported (Freeman, 1992). If dedicated solely to vehicles, this volume would displace about seven percent of the total ground sector fuel consumption projected for 1996. However, Hawaii LPG is currently used for cooking, water heating, and other fueling needs, particularly in remote areas. It is not clear how these non-transportation needs would be met if LPG were redirected to vehicle use. Since Hawaii already imports propane to satisfy existing demand, imports would have to increase to supply the transportation sector. Without a local natural gas supply, LPG does not score well under the energy security criterion.

LPG vehicles are commercially available, typically as standard gasoline vehicles sold in "conversion-ready" form. The upfitted vehicles are sold at costs somewhat higher than comparable conventionally fueled vehicles. Vehicles are dedicated, rendering a propane strategy relatively inflexible (although "reconversion" is possible). However, with fuel and vehicles available at low incremental cost compared with gasoline, propane could be used to some degree in vehicles immediately with little cost and effort. For example, the City and County of Honolulu has 139 LPG-fueled vehicles (Miura, 1994).

Conclusions

LPG does not meet the first criterion of providing energy security for Hawaii as well as some other alternative fuels. It cannot be produced from indigenous resources and must either be produced locally from imported crude oil or imported. However, imported LPG may offer increased supply and price stability compared with imported crude oil. A LPG strategy for Hawaii would involve importing a significant amount of LPG, expanding local refinery production, or redirecting LPG from existing users. Because engines and vehicles are available and publicly accepted, and because The Gas Company supports an active LPG vehicle market in Hawaii, LPG vehicles will likely fill much of the initial EPACT demand for alternative fuel light trucks and vans in Hawaii. However, an imported fuel does not well satisfy the "energy security" goal. LPG does not satisfy the third criterion of benefiting the Hawaii economy to the same degree as a fuel which could be produced on a large scale locally. A number of jobs could be created to retrofit/convert vehicles to LPG, but the benefit of a LPG conversion industry to the Hawaii economy would be much smaller than the benefit of a local fuel production industry. Furthermore, LPG vehicles are dedicated, not offering the flexibility of alcohol FFVs or electric vehicles. Therefore, although LPG provides environmental benefits and shows potential to supply a large volume of fuel (under an import scenario) at competitive costs, government measures to increase transportation use of LPG will not be a focus of this study.

However, it is important to note that LPG has already been implemented. LPG vehicles have been operated in Hawaii for years. Once EPACT tax deductions are taken into account, upfitted LPG vehicles are cost competitive with gasoline vehicles, and The Gas Company has stated that it would price LPG to be competitive with gasoline on an energy equivalent basis (Freeman, 1992). For these reasons, LPG is finding its own niche in Hawaii fleets.

5.2.7 CONCLUSIONS OF THE SCREENING ANALYSIS

Table 5-1 shows the results of the screening analysis. Fuel options were rated in relation to each other, with a "+" as the top score, a "0" as the next best score, and a "-" as the lowest score. Note that the use of "0" as one of the symbols is not intended to indicate that a fuel option rates equal to some undefined baseline; it simply indicates a rating in between good (+) and not-so-good (-). Fuel options receiving all "+" ratings for the strategic criteria "pass" the screen. A "pass" indicates that large scale use of these fuel options appear in the long-term to be the most beneficial for Hawaii, and that these fuels should therefore receive the most attention and support from the state. The ratings are based on our current understanding of technology status, the political and economic environment, and other factors. This screening analysis should be evaluated periodically.

What emerged as the key factor in this comparison of options was whether the fuel could be produced in the state from locally available feedstocks at a low enough cost that the same fuel, imported, was unlikely to capture market share. Fuels expected to be producible from local resources and competitive with imports received high ratings for energy security and economic benefits, two major strategic criteria.

Fuels not passing the screen may still have a role in Hawaii's alternative energy future. However, programs to introduce alternative fuels into the transportation sector are costly and require public support. Therefore, it is important to identify which fuels are most consistent with the state's goals. The majority of the state's effort and resources could then be focused on the introduction of those fuels which are expected to provide Hawaii with the most benefits in the long-term. Other alternative fuels are acceptable, but may not warrant the same level of state encouragement.

We conclude that alcohols, electricity, and to a slightly lesser degree biodiesels deserve the most public attention and state support. These fuels meet strategic criteria by having the potential to be produced from indigenous resources, providing Hawaii with increased energy security and benefiting the state economy. Alcohols and electricity have the potential to supply a substantial volume of transportation energy using local feedstocks. In addition, vehicles using these fuels (including conventional vehicles in the case of biodiesels) are expected to be increasingly available. Strategies employing any of these fuels would be comparatively low-risk and flexible, and the costs of these fuels are not linked to oil prices (assuming electricity is generated from renewable resources). Finally, all of these fuels could provide environmental, health, and safety benefits if properly handled and used. In light of these considerations, the remainder of this report will focus on these fuels.

Hydrogen rates well in terms of the strategic criteria, but poorly under near-term considerations. However, as hydrogen appears to be a potentially strong candidate for eventual large-scale use in Hawaii's transportation sector, we recommend that hydrogen production from renewables, hydrogen storage, and hydrogen vehicle technology be followed closely by the state.

In addition, LPG is an alternative fuel with a role to play in Hawaii. Although LPG does not fully satisfy the strategic criteria, it is one alternative fuel that could be implemented easily and at low cost. In addition, it has support from the local LPG industry. Therefore, alternative fuel requirements are likely to result in some LPG use, and the ease of LPG implementation could provide other alternative fuels programs with momentum and added credibility.

CHAPTER 6

INFRASTRUCTURE FOR TRANSPORTATION FUELS

6.1 INTRODUCTION

It is essential that any program to substitute alternative fuels for conventional fuels include a plan for how the alternative fuel is to be distributed and marketed. What is the existing network of fuel infrastructure? What modifications to the existing fuel distribution system are required? What new issues, unique to the alternative fuel and its new use in the transportation sector, must be considered? For liquid and gaseous fuels, how will the distribution and marketing affect "at-the-pump" prices and how will this vary with station throughput and statewide sales volume? For electricity used as a transportation fuel, what must be done to supply electric vehicle users with safe, convenient refueling capability, and what effect will this new market have on the utility system? This chapter briefly describes existing infrastructure as well as infrastructure modifications and special considerations associated with alternative fuel options (alcohols, biodiesel, electricity, and propane) identified by the screening analysis (Chapter 5) as having the potential to meet Hawaii's energy goals.

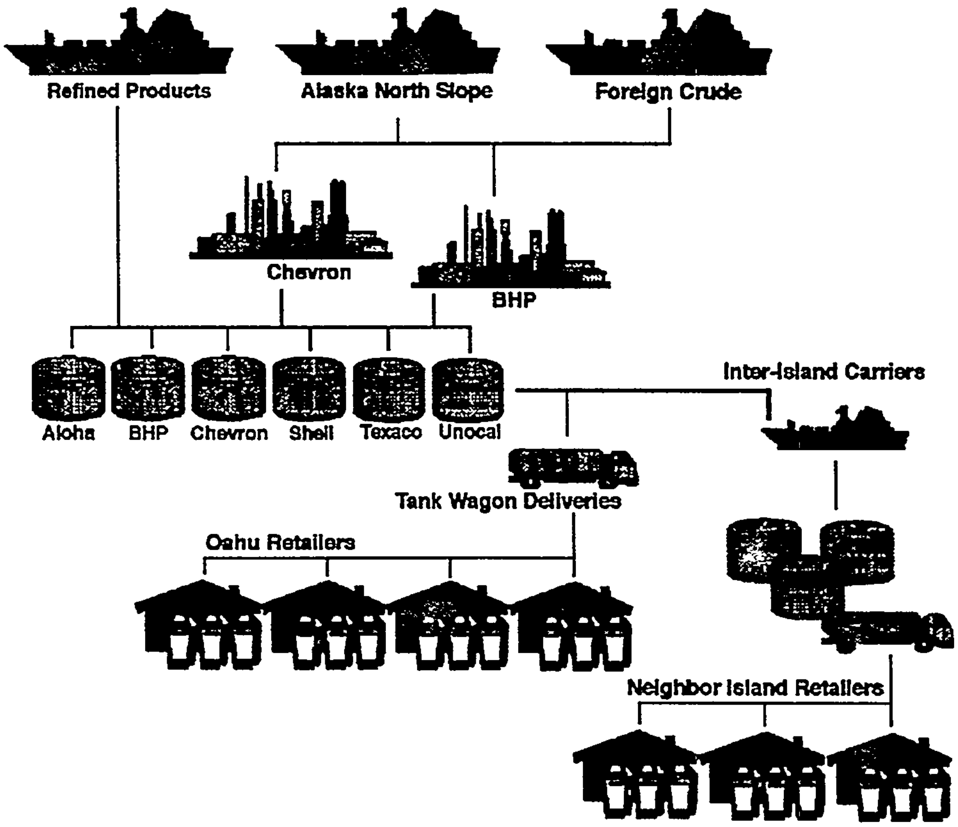
6.2 EXISTING INFRASTRUCTURE

6.2.1 CONVENTIONAL FUELS

Figure 6-1 shows the distribution of gasoline in Hawaii. In Hawaii, Chevron U.S.A. and BHP Petroleum Americas Refining, Inc. (BHPPAR) refine crude oil which is imported through offshore mooring facilities at Barbers Point. Refined products are transported via pipelines from the refineries at Campbell Industrial Park to bulk storage facilities at the Honolulu Harbor terminal complex. Ninety percent of the petroleum used in Hawaii passes through the complex at the Honolulu Harbor; about 80 percent of the fuel comes from the local refineries while the rest is delivered by tankers from West Coast refineries. Aloha Petroleum, Chevron, Shell Oil Company, BHPPAR, Hondo Oil and Gas, Isle Gas, Hawaiian Electric, Hawaii Fuel Facilities Corporation, and Unocal operate facilities at Honolulu Harbor with a combined storage capacity of over 3 million barrels (126 million gallons) of fuel including three grades of gasoline, two grades of diesel, jet fuel, residual oil and asphalt. Tanker trucks load at five truck racks to service the Oahu market, while barges transport fuel to the other islands. Texaco loads its tank trucks from its truck loading rack in Campbell Industrial Park at Barbers Point (State of Hawaii, Department of Business, Economic Development & Tourism, 1991a; Jason Lembeck & Associates, 1989; Williams Brothers Engineering, 1992).

Figure 6-1

Distribution of Gasoline in Hawaii



Source: The Energy Division, State of Hawaii Department of Business, Economic Development & Tourism

Note: Most Hawaii gasoline and diesel starts out as crude oil brought in by tankers. Two local refineries process the crude oil into the products sold by various companies to gas stations.

On Oahu, nearly 70 percent of the fuel from the racks is delivered to stations in a region between Pearl City and Hawaii Kai (Jason Lembeck & Associates, 1989). The tanker trucks load up at the terminal rack and transport the fuel to a refueling facility (retail station, bus refueling facility, fleet refueling station, etc.) where the fuel is transferred to the underground tank. Typical tanker truck capacity is about 8500 gallons (Cassulo, 1993). Typical underground tank capacity is about 10,000 gallons.

Chevron is the largest distributor of gasoline in Hawaii, the other major companies are Shell, Texaco, and Unocal. Gas Express markets gasoline and diesel for BHPPAR. Jobbers which own stations include Aloha Petroleum on Oahu, Maui Petroleum on Maui, and Akana on the Big Island (Schoen, 1992). Other companies, including Fastop and 7-11, sell gasoline as well. Most of the stations store three grades of gasoline: regular, premium, and midgrade, although a number of stations store only regular and premium. Gas Express and Unocal make midgrades at the station using a blending pump in order to avoid the need for an extra tank to store midgrade gasoline (Cassulo, 1993). Roughly 15 percent of the stations on Oahu sell diesel fuel as well (State of Hawaii, Department of Agriculture, 1992.)

6.2.2 PROPANE

Propane is purchased, stored, distributed, and sold in Hawaii by The Gas Company, Inc., (GasCo), Oahu Gas Service, and Aloha LP Gas. Of these, GasCo holds the largest market share.

GasCo purchases propane from Hawaii's two refineries, BHPPAR and Chevron, which produce propane as a byproduct of oil refining. Propane is distributed in small storage tanks as a pressurized liquid; the tanks are either transported by truck or, for transport between islands, by barge. Trucks haul propane tanks to a network of storage tanks serving over 40 GasCo propane vapor distribution systems. From these tanks, located on Oahu, the Big Island, Maui, Kauai, and Molokai, the propane is vaporized and distributed through underground distribution lines to GasCo customers. In 1992, these systems accounted for about 14 percent of GasCo's total utility sales (The Gas Company, Inc., 1993). A summary of distribution systems by island is shown in Table 6-1 (The Gas Company, Inc., 1993).

In addition, many propane vehicle refueling facilities already exist in Hawaii. Some of these are retail stations and some only serve fleets. GasCo supplies approximately 10 propane stations on Oahu, approximately 45 stations statewide, and Oahu Gas Service and Aloha LP also supply a few more. Distributors include Chevron, Unocal, Shell, Gaspro, Gas Express, and wholesalers (Kepoo, 1994).

According to GasCo's Integrated Resource Plan, submitted to the Hawaii Public Utilities Commission in May of 1993, the existing propane storage and distribution systems have sufficient excess capacity to accommodate more than the growth in load projected through 2011. Furthermore, in the case of higher growth than projected, such as might occur if a significant number of additional propane vehicles came into use in Hawaii, GasCo states that the capacity of the systems could be increased at minimal cost (The Gas Company, Inc., 1993).

Table 6-1

GasCo Propane Vapor Systems (1992)

Island	No. of Vapor Systems	No. of Customers	Average Annual Sales (Therms)	Storage Capacity (Therms)
Oahu	30	3,583	1,580,665	137,294
Hawaii	4	1,799	2,276,483	1,071,214
Maui	5	395	784,028	49,302
Kauai	3	377	68,706	12,052
Molokai	1	20	2,583	1,826
Total	43	6,174	4,712,465	1,271,688

Source: The Gas Company.

6.2.3 ELECTRICITY

Approximately 75 percent of the State of Hawaii's electricity generation in 1993 was fueled by petroleum (State of Hawaii, Department of Business, Economic Development & Tourism). The balance of the generation mix is comprised of biomass, hydroelectric, wind, solar (photovoltaic), geothermal power, and coal. The amount of electricity that will be generated in Hawaii from coal will increase over the next two decades (Yamaguchi, 1993).

Four companies distribute electricity in the State of Hawaii. These are: Hawaiian Electric Company (HECO), Hawaii Electric Light Company (HELCO), Maui Electric Company (MECO), and Kauai Electric Division, which is a division of Citizen's Utilities. HECO is the parent company of HELCO and MECO. MECO operates on Lanai and Molokai as well as on Maui.

HECO and HELCO are actively supporting electric vehicle (EV) programs. HECO has operated an electric G-Van since July of 1991 (Waller, 1993). The company is also a key participant in the Hawaii EV Demonstration Program being sponsored by the Advanced Research Projects Agency (ARPA) and is investigating ways to facilitate EV use in Hawaii.

HECO is especially interested in EVs as a way to increase the nighttime load. In part due to independent power producer (IPP) power supply which HECO is required to purchase, HECO has more power available at night than is currently needed. In other words, the nighttime load (demand for electric power) is currently below the minimum load needed to use all of the power being generated. Additional electricity demand from EV nighttime charging would help the utility to meet minimum load requirements.

6.3 STORAGE, DISTRIBUTION, AND MARKETING OF ALTERNATIVE FUELS

6.3.1 ALCOHOLS

According to the American Petroleum Institute (API), there are four key considerations associated with alcohol and alcohol blend infrastructure:

- water tolerance and fuel contamination;
- materials compatibility;
- volume; and
- fire and explosion hazards.

In general, low-level blends of alcohol (up to ten percent ethanol) with gasoline are handled like gasoline; high-level blends (over eighty-five percent alcohol) are handled like alcohol. Requirements for low-level and high-level blends are discussed separately below.

6.3.1.1 Low-Level Alcohol Blends (gasohol)

Blends of gasoline with small quantities of alcohol (up to ten percent ethanol, referred to as E10) may be used in modern conventional vehicles with no modification. All manufacturers approve the use of up to ten percent ethanol. Methanol blends in the U.S. are currently extremely rare, since most methanol for use as an automotive fuel is converted to the additive known as methyl tertiary butyl ether (MTBE). Since ethanol (rather than methanol) blends are the most commonly discussed and widely available of the low-level gasoline/alcohol blends, the remainder of this section will focus on blends of gasoline with up to 10 percent ethanol by volume.

6.3.1.1.1 Historical Background

Vehicles and fuels have both gone through many changes over the years, even without considering alternative fuels and alternative fueled vehicles (Downstream Alternatives, Inc., 1992). Conventional gasoline vehicles of the 1990s are significantly different from conventional gasoline vehicles of the 1960s (and other decades) (Gunnel, 1993); the gasolines used to power these vehicles are also different. Understanding the changes in vehicle and fuels is necessary to understanding the history of additives such as ethanol in gasoline.

The increased use of ethanol blends in the late 1970s and early 1980s was in response to the oil price shocks of 1974 and 1978; ethanol was added to gasoline as a "gasoline extender." More widespread use of ethanol began in the mid-1980s, as the phasedown of lead caused refiners and retailers to look for other additives to boost gasoline octane; ethanol was added to gasoline as an "octane enhancer." In the 1990s, with the Clean Air Act Amendments requiring carbon monoxide non-attainment areas to use oxygenated fuels, ethanol is being added to gasoline as an "oxygenate."

Although a complete discussion of the history of automotive technology, changes in fuels, and composition and purpose of additives is not possible here, examples of some of the major changes are the following: control of automotive emissions (positive crankcase ventilation valves, catalytic converters, exhaust gas recirculation systems, evaporative canisters, computer controls and sensors); changing fuel economy standards; changes in compression ratios and changes in vehicle octane requirements; fuel injection systems; lead phaseout; increases in fuel aromatics; increases in fuel volatility; and addition of detergents/deposit control additives, fluidizer oils, corrosion inhibitors, anti-oxidants, metal deactivators, and octane enhancers. Problems encountered when some of these changes were first introduced have been resolved; modern fuels and modern vehicles are designed to work together, as long as both the vehicles and the fuels meet the required specifications.

Low-level ethanol blends are generally handled like gasoline, with two major differences: due to water tolerance considerations, ethanol is blended with the gasoline at the terminal, at the point where the final graded fuel is loaded onto trucks for delivery to service stations (ethanol-blended fuel is not generally shipped through refined product pipelines); and, when a retail station is changing over from non-ethanol-blended fuels to ethanol blended fuels, some basic housekeeping measures are required at the time of changeover.

6.3.1.1.2 Water Tolerance (E10)

Water is always present in current gasoline distribution and storage systems. This does not create problems because water separates from gasoline and sinks, creating a "water bottom" or layer of water at the bottom of storage tanks that can be drained at any time. The introduction of water into alcohol blends, however, is problematic. Small amounts of water will blend into alcohol mixtures without causing any problems. If larger amounts of water are present, however, water in the mixture will extract much of the alcohol and sink to the bottom of a tank, resulting in a water bottom which is a mixture of alcohol and water.

Alcohol/water bottoms must be avoided. The first step to avoiding alcohol/water bottoms is housekeeping before changing over to an ethanol blend. First, the tank should be tested for water bottoms; all water should be pumped out. If the tank is old and contains significant amounts of sediments, additional cleaning is recommended. An ethanol-compatible fuel filter should be installed on each gasoline dispenser (two, if there's a hose on either side).

The water issue is more an issue of good housekeeping. Underground storage tanks at service stations have a dispensing pipe that comes down to within a few inches of the bottom of the tank. If there's too much water in the tank, the water level will be above the pipe intake and water will be pumped out - even without the presence of ethanol. If water is getting in there at a rapid rate, (i.e. the tank is leaking) there is a problem whether or not the gasoline contains ethanol. Knowing the rate at which the water accumulates, and knowing the frequency of gasoline deliveries, any problems can be anticipated and corrected prior to adding ethanol blends to the system.

At the terminal and the refueling station, equipment should be inspected and precautions taken to ensure that the system is water-tight, or "dry". The refueling station operator should test periodically water bottoms (using an appropriate paste, as the usual pastes are ineffective for alcohol blends) and, if found, should pump out the water/alcohol mixture immediately, taking appropriate safety precautions for handling a flammable mixture (API 1626, 1627, 4261; EPA, 1990).

6.3.1.1.3 Materials (E10)

In general, most materials used in modern gasoline and diesel storage and distribution are compatible with alcohol blends. Table 6-2 (API 1626) shows commonly used materials and their suitability for use with ethanol or low-level ethanol blends. Table 6-3 (American Petroleum Institute, 1986) shows commonly used materials and their suitability for use with low-level methanol blends.

6.3.1.1.4 Fire Hazards and Explosion Hazards

Low-level alcohol blends present approximately the same fire and explosion hazards as pure gasoline. The blending sequence should provide for gasoline to be added to the tank truck before the ethanol, for reasons which are described in the section on high-level blends and neat alcohols.

Codes, standards, and recommended practices for the safe handling of gasoline should be followed.

6.3.1.2 Neat Alcohols And High-Level Alcohol Blends

Alcohol fuel is generally provided as a blend of 85 percent ethanol or methanol and 15 percent gasoline for light-duty alternative fuel vehicles and as a "neat" fuel (100 percent methanol or 100 percent denatured ethanol) for heavy-duty alcohol-fueled vehicles.

6.3.1.2.1 Water Tolerance (M85/M100/E85/E100)

Water is always present in current gasoline distribution and storage systems. This does not create problems because water separates from gasoline and sinks, creating a "water bottom" or layer of water at the bottom of storage tanks that can be drained at any time. The introduction of water into high-level alcohol blends, however, is problematic. Flexible-fuel vehicles are designed to run on a mixture of pure gasoline, 85% alcohol or any combination in between; they are not designed to run on unspecified combinations of alcohol and water.

Table 6-2

Compatibility of Commonly Used Materials with Ethanol and Ethanol Blend

Recommended	**Not Recommended**
Metals	
Aluminum	Zinc-galvanized (ethanol only)
Carbon steel	
Stainless steel	
Bronze	
Elastomers	
Buna-N (hoses and gaskets)[1]	Buna-N (seals only)[1]
Fluorel[1]	Neoprene (seals only)
Fluorosilicone[2]	Urethane rubber
Neoprene (hoses and gaskets)	
Polysulfide rubber	
Natural rubber (ethanol only)	
Viton[1]	
Polymers	
Acetal	Polyurethane[2]
Nylon	Alcohol-based pipe dope (recently applied)[2]
Polyethylene	
Polypropylene	
Teflon[1]	
Fiberglass-reinforced plastic[2]	

Source: American Petroleum Institute.

Notes:

1) Registered trademark.

2) The manufacturer of the specific material should be consulted.

Table 6-3

Compatibility of Commonly Used Materials with Gasoline-Methanol/Cosolvent Blends

Recommended[1]	Not Recommended
Metals	
Aluminum Carbon steel Stainless steel Bronze	Galvanized metals
Elastomers	
Buna-N[2,3] Fluorel[2] Fluorosilicone[4] Neoprene[3] Polysulfide rubber Viton[2]	Buna-N[2,3] Neoprene[3]
Polymers	
Acetal Nylon Polyethylene Polypropylene Teflon[2] Fiberglass-reinforced plastic[4]	Polyurethane[4] Alcohol-based pipe dope (recently applied)[4]

Source: American Petroleum Institute.

Notes:
1) These recommendations may not apply to phase-separated mixture or to the gasoline-methanol/cosolvent blending components. The manufacturer of the specific material should be consulted.
2) Registered trademark.
3 Buna-N and neoprene are recommended for hoses and gaskets but not seals.
4) The manufacturer of the specific material should be consulted.

The storage and distribution of neat and high-level alcohol blends on the islands must be designed to prevent water contamination. This means that alcohol storage and dispensing systems must prevent the introduction of water or humid air. A tank at a terminal facility should have a fixed roof and an internal floating cover. At the terminal and the refueling station, equipment should be inspected and precautions taken to ensure that the system is water-tight, or "dry". The refueling station operator should test periodically for a water bottom in the alcohol tank (using an appropriate paste, as the usual pastes are ineffective for alcohol blends) and, if one is found, should pump out the water/alcohol mixture immediately, taking appropriate safety precautions for handling a flammable mixture (API 1626, 1627, 4261; EPA; 1990).

6.3.1.2.2 Materials (M85/M100/E85/E100)

In general, most materials used in gasoline and diesel storage and distribution are compatible with alcohol and alcohol blends. However, certain materials are not suitable because alcohol can corrode metals and dissolve certain substances. Alcohol is also electrically conductive. These characteristics can result in failed components throughout the distribution system, for example, leaking seals and plugged fuel filters. They can also result in alcohol fuel becoming contaminated with small amounts of metals and other substances which can harm alcohol-fueled vehicles.

The material compatibility of every component which contacts alcohol fuel must be considered. This includes storage tanks, hoses, piping, fittings, seals, pumps, meters, and dispensers. As stated above, the use of the wrong materials may lead to failure of the dispensing system or failure of a vehicle fueled with alcohol.

Unlined steel tanks can be used with alcohol fuels, but since the solvent characteristics of the alcohols can loosen rust and other contaminants from the tank walls, tanks previously used to store gasoline or diesel fuel must be flushed before use with alcohol (API 1626, 1627). If tank trucks used to transport gasoline or diesel are used intermittently to transport alcohols, they must be steam-cleaned before being filled with alcohol. Internally lined tanks and fiberglass-reinforced plastic tanks may or may not be alcohol-compatible; manufacturers should be consulted before attempting to use a tank of one of these types for alcohol storage.

Similarly, existing steel piping can be used but nonmetallic piping may not be suitable. Again, the manufacturer should be consulted. Piping used previously must be flushed, as well, to remove contaminants. Fuel pumps must be alcohol-compatible; again, the pump manufacturer should be contacted. Alcohol-compatible materials must be used for all fittings and seals.

Table 6-2 (API 1626) shows commonly used materials and their suitability for use with ethanol. Table 6-3 (API 1627) shows commonly used materials and their suitability for use with methanol.

Material compatibility is a more acute problem for neat methanol than for ethanol and is the subject of ongoing research. Metals to be avoided include lead, magnesium, and platinum and coatings of copper (or copper alloys), zinc, or aluminum. Some types of brass and tin may also be incompatible with methanol. Mild steel alloys are recommended for use with methanol (Canadian Oxygenated Fuels Association, 1992). Nonmetallic components used successfully with methanol include nitrile (Buna-N), polyethylene, polypropylene, and neoprene elastomers (COFA, 1992).

Field experience continues to provide useful knowledge about materials and components that do and do not work with neat methanol; for example, it has been found during the course of California programs that teflon tape should not be used and must be replaced with an alcohol-compatible pipe sealant (Sawyer 1993). Recent data collected by General Motors on fuel filter plugging in the Chevrolet Lumina fuel-flexible vehicles has raised concerns of unacceptable levels of aluminum hydroxide in methanol fuel which may be a result of unprotected aluminum surfaces in the fuel dispenser. The compatibility of dispenser hoses used with methanol continues to be evaluated as well; elastomers in the hoses appear to leach out into the methanol fuel and to gel in the fuel when the fuel temperature drops. This may also cause fuel filter plugging. More work is needed to ensure complete compatibility of storage and refueling hardware with neat methanol fuel.

6.3.1.2.3 Volume

This refers to the lower energy content of alcohol fuel compared with conventional fuels. Because alcohol has a lower energy content than gasoline or diesel, 1 million alcohol vehicles driving 30 miles per day would require a greater volume of fuel than 1 million gasoline or diesel vehicles also driving 30 miles per day. Infrastructure-related volume considerations, such as increased bulk storage capacity and/or higher throughput, more trucks to distribute bulk fuel, and increased pipeline capacity, are usually discussed in the context of a possible future in which alcohol replaces a large portion of gasoline and diesel transportation fuel nationwide. Fuel energy content disparities affect the life-cycle incremental cost of operating an alcohol vehicle and are included in the cost analyses (Chapter 8). Any alcohol infrastructure planning in Hawaii should properly account for the energy content of the fuel, recognizing that to achieve equivalent mobility approximately 1.5 - 2 gallons of alcohol must be stored and distributed for every gallon of gasoline that would otherwise be used.

6.3.1.2.4 Fire Hazards and Explosion Hazards (M85/M100/E85/E100)

Neat alcohols and high-level alcohol blends have advantages and disadvantages compared with the fire and explosion hazards presented by gasoline and diesel fuel.

Neat alcohols pose less of a fire or explosion risk than gasoline or diesel in the case of a spill or release of vapor because the latent heats of vaporization and the lower flammability limits of methanol and ethanol are higher than those of gasoline. In other words, alcohol will cool more quickly as it evaporates (or burns) than gasoline; and alcohol vapor, dispersing in open air, reaches the point where the amount of alcohol vapor in air is too small to ignite (in other words, too lean to ignite) earlier than gasoline.

In an enclosed space, such as a fuel tank or a tank truck, however, alcohol vapor which fills the space above the liquid in the tank is typically within the flammability limits and thus poses a fire/explosion hazard whereas gasoline, which is more volatile than alcohol, vaporizes to fill the vapor space with a mixture of gasoline and air too rich to ignite. For this reason, it is preferred to transport E85 or M85 mixtures rather than pure alcohol; the vapor above an alcohol-gasoline blend will contain much more gasoline vapor than alcohol vapor, and will therefore present less of a fire or explosion hazard.

Finally, for methanol more so than ethanol, the flames from a neat fuel (100 percent methanol) fire are essentially invisible in sunlight. This can cause a serious public safety hazard because people may fail to recognize the presence of a fire. It is partly to avoid such invisible fires that alcohol/gasoline blends, such as M85 or E85, are used instead of neat alcohols in light duty vehicles (alcohol-fueled buses, however, are often designed to operate on neat fuels with appropriate safety precautions). Less visible flames have an safety advantage, as well; this results in less radiative heat transfer from the flames back to the pool of alcohol which is burning so that the fire is not exacerbated by its own heat, as is a gasoline or diesel fire which effectively "feeds" itself. The combination of the low flame luminosity, the high heat of vaporization (increased cooling of an alcohol fire), and the lower energy content of the alcohols compared with gasoline, result in alcohol fires, once underway, being far less hazardous than gasoline fires, except to the extent that the alcohol fire is less visible.

In practice, these safety issues should be addressed in several ways. Alcohol fuels should be properly stored and transported and fire suppression systems should be installed as appropriate. Codes, standards, and recommended practices should be followed, and personnel should be trained in alcohol handling. Local fire departments should be aware of the location of all alcohol facilities and should be prepared to handle alcohol fires.

6.3.1.2.5 Infrastructure Guidance (M85/M100/E85/E100)

In addition to codes, standards, and recommended practices of the API and others, a few references exist which provide detailed, specific hardware requirements for an alcohol refueling facility. For example, a publication of the Canadian Oxygenated Fuels Association titled "Methanol Fueling Systems Guide," lists equipment specifications, component vendors, safety advice, and other practical information and addresses all of the issues described above. The report references Canadian and U.S. codes and recommended practices (COFA, 1992). A similar publication, "Outline Specification for the Installation of Methanol M85 Tanks & Piping" was produced by Mohawk Norwood Service (Mohawk, 1993). Alcohol vehicle manufacturers such as Ford have helpful documentation available, as well (Ford Motor Company, 1993). The California Energy Commission is in the process of developing a similar guidance document which will incorporate the valuable field experience gained over the past decade through the state's methanol programs.

6.3.2 BIODIESELS

Biodiesels do not require substantial changes to the current fuel distribution system or any safety practices beyond those which would apply to regular diesel. As biodiesel can erode rubber, any rubber fuel hoses or seals which would contact biodiesel should be replaced with biodiesel-compatible components (Ayers, 1993). Once rubber components have been replaced, theoretically, there should be no barrier to biodiesels being added to regular diesel fuel at the terminal or at the refueling station.

6.3.3 ELECTRICITY

While electricity is very widely used to meet power requirements in residential, commercial, and industrial settings, EV use will create many new infrastructure requirements. EV-related infrastructure will include charging stations at residences, public locations, and businesses; battery recycling and disposal facilities; and possibly provisions for fast charges or changing out dead batteries for fully charged batteries in the case of vehicles "running out of gas", so to speak. EVs will also require unique modifications to existing practices. Maintenance and repair personnel will require special training in order to provide service to EV owners. Federal Motor Vehicle Safety Standards (FMVSS) and other codes will need to be amended to include standards appropriate for EVs and EV charging stations. Finally, utilities will need to assess the impact of load increases associated with increasing numbers of EVs in their system and take action to ensure that the EVs are optimally integrated into the system.

6.3.3.1 EV Charging

Many charging options are being considered. These include:

- home charging, typically assumed to take place overnight and thus take advantage of off-peak electricity rates (cost savings depends on the rate structure of the local utility which can be adjusted to encourage overnight charging as a load-leveling strategy);
- opportunity (daytime) charging, which assumes that charging stations are available in public places such as shopping malls or parking lots, and/or businesses; and
- quick-charge or battery swapping station, where the EV "gas station" is a facility which provides fast charges with high-amperage chargers or accepts discharged batteries and offers charged batteries as replacements.

Charging considerations will vary to some degree for hybrid EVs; for example, hybrid vehicle owners might prefer to have the option of charging or battery swapping at gasoline stations where they could simultaneously fill their gasoline tanks.

Charging can be accomplished in a number of ways; home charging would be accomplished with a standard 120 or 240 volt outlet and, although it would take up to four to eight hours[1] (depending on the vehicle, batteries, and level of discharge), would not present much difficulty. Opportunity charging in public places or places of business could be installed for customer convenience. Solar (photovoltaic) panels could be installed in sunny locations to provide both shady parking spaces and opportunity charging for electric vehicles, and would avoid increasing the electrical demand on the utility during daytime hours.

Higher-voltage charging facilities might also be installed at residences not originally equipped for vehicle access to electrical power, such as apartment buildings. Standardized charging interfaces should be developed and used in all charging facilities and vehicle charging systems in order to meet consumer mobility needs, although EV manufacturers are beginning to provide flexibility in the charging interfaces on board the vehicle to overcome the current lack of standardization.

Another method for charging a battery quickly which might be used in future years is inductive coupling, where a magnetic field is generated to transfer power to the battery (McCoy 1993). Inductive charging could be accomplished at a charging station or, as some propose, while the vehicle is in motion via a roadway charging system. The "roadway powered electric vehicle" would receive electromagnetic energy from inductor units built into the road along its centerline. A component similar to an antennae would receive the power and use it to power the vehicle and recharge the battery for use on roads not equipped with inductors (see Figure 6-2) (Ross, 1992). Such a strategy is not likely to be implemented in the near-term, however.

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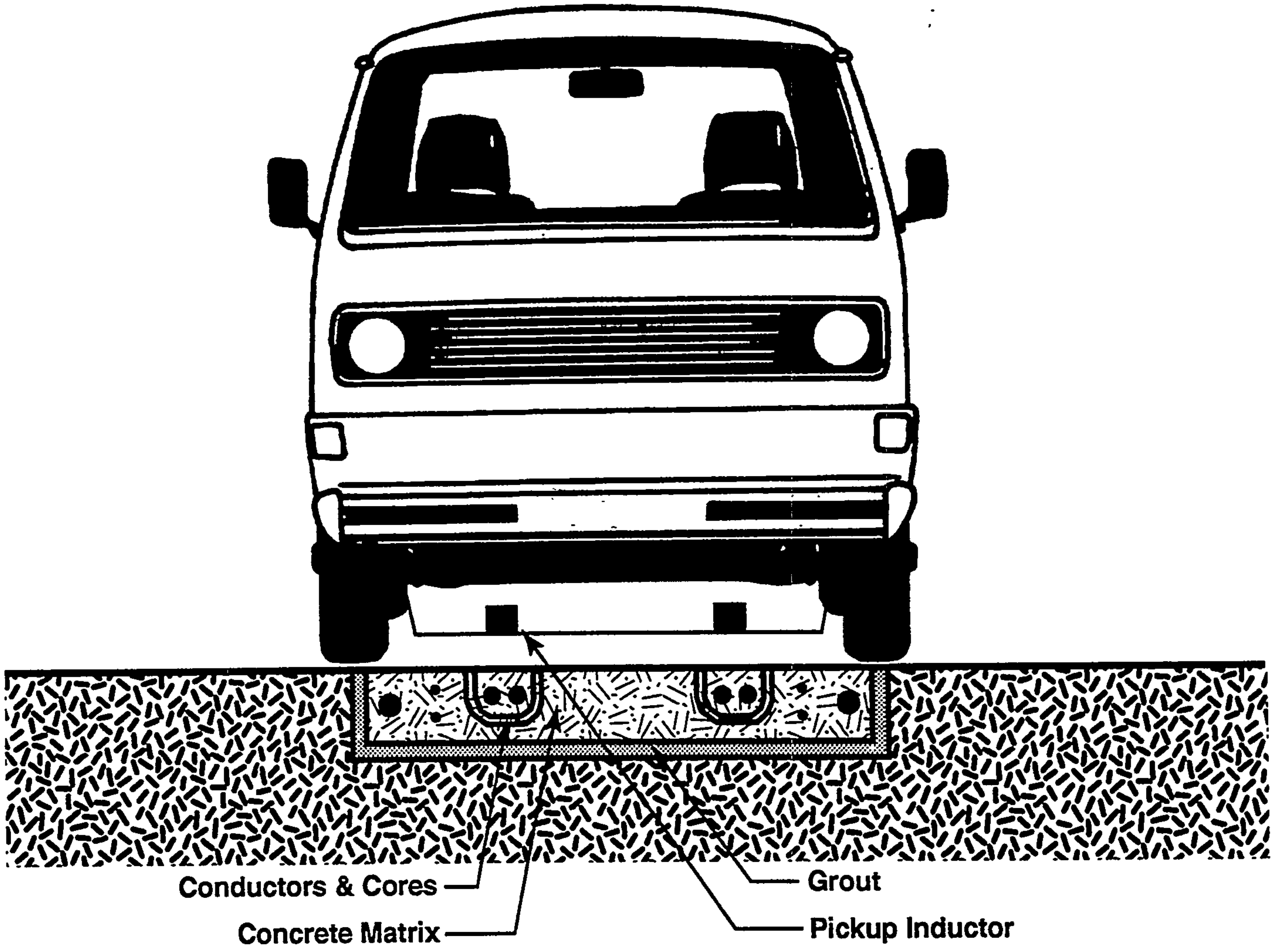
[1] U. S. Department of Energy, *Taking an Alternative Route,* 1994.

Figure 6-2

Inductors Imbedded in the Road Charge EVs During Use



Cross-Section of Vehicle and Roadway

Source: Acurex Environmental

Battery swapping would require a facility to accept discharged batteries, charge them, and provide them to customers for an appropriate price. The advantages of such a system include the customer convenience associated with the rapidity of exchanging batteries relative to longer charging times, and the ability of the swapping facility to charge batteries slowly and primarily during off-peak hours provided the facilities' stock of batteries is sufficiently large to meet customer demands. Battery-swapping has many disadvantages, however, and is unlikely to become the main charging strategy for EVs. To a large extent, EVs would have to be designed to a standard which would allow efficient and uniform battery replacement. Batteries would need to be fungible. Consumers would be at the mercy of whichever battery was last installed in their vehicle; similarly, consumers would be more likely to abuse a battery that they did not own. Vehicle range and performance could change by up to 40 percent from one battery to the next in a swapping scenario (Allison, 1991). Studies have estimated that once EVs have captured a large market share, the physical practicalities of a battery-swapping system, such as facility layout, exchange of battery inventory between facilities, and so forth, would be very burdensome. In order to smooth facility service, the system-wide battery-pack inventory would need to substantially exceed the number of EVs utilizing the system, which would increase overall operating costs.

6.3.3.2 Batteries

EVs currently use about 20 times the number of lead-acid batteries that conventional vehicles use (Alternative Fuels Insider, 1993). As EVs come into wider use, battery recycling and disposal systems will have to keep up with the increased demand, whether lead-acid or a more advanced type of battery is used.

Of the approximately 20 battery technologies currently being investigated for use in electric vehicles, several have matured to the point where industry is willing to commit considerable resources on vehicle test programs. These include the following (California Air Resources Board, 1993) :

- lead-acid (conventional, tubular, bi-polar, etc.);
- nickel-cadmium;
- sodium-sulfur;
- sodium-nickel chloride;
- nickel-metal hydride; and
- lithium-polymer.

While the United States is equipped to recycle the current supply of spent conventional lead-acid batteries, and two facilities in the United States are currently capable of recycling large nickel-cadmium batteries (California Air Resources Board, 1993), the recycling technology and infrastructure needed to accommodate advanced lead-acid technologies and other battery technologies is still under development.[2]

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[2] The recycling of these batteries can present significant environmental and health hazards. In 1985, EPA declared spent lead-acid batteries, if disposed, to be a hazardous waste. In addition, many of the substances resulting from the recycling process are hazardous wastes individually. Other battery technologies pose serious environmental and health threats, as well; cadmium, for example, is very toxic, and rechargeable batteries are responsible for most of the cadmium in landfills today (Lewis, 1993).

By weight, 98 percent of a conventional lead-acid battery can be recycled. A conventional lead-acid battery contains 17.5 to 20 pounds of lead, 9 to 11 pounds of sulfuric acid, and 1.6 to 3 pounds of polypropylene for the case (Lewis Center for Regional Policy Studies, 1993). Other battery technologies involve different chemicals, metals, and physical design. The recycling of conventional lead-acid batteries requires the spent batteries to be broken apart. The acid is drained, neutralized, and discharged to wastewater treatment systems. Cases are ground and recovered and sent to plastic recycling facilities, and all lead scrap is melted. Slag formed from lead sulfide in the furnace must be processed as a hazardous waste (Lewis Center for Regional Policy Studies, 1993).

Currently, lead-acid car batteries are not recycled in Hawaii. Several companies accept spent car batteries and prepare them for recycling, the batteries are shipped out of state to be processed. According to a representative of the Hawaii Hazardous Waste Branch of the Department of Health, a battery recycling facility would need to apply for a solid waste management permit and a hazardous waste permit, but no special regulations prevent a battery recycling facility from being built on the islands (McCabe, 1994).

6.3.3.3 Maintenance And Repair

EV technology is drastically different from the technology of the internal-combustion vehicle. In order to service EVs, the mechanic will need not only general automotive skills, but general electrical skills including a working knowledge of low and high voltage electrical systems and the ability to test and repair DC or AC electric motors, controllers, converters, chargers, and battery packs. Special equipment will be needed to perform EV service (McCoy and Lyons, 1993).

6.3.3.4 Codes And Standards

Although many vehicle-related codes and standards are inappropriate for EVs, EV manufacturers are aware of the public's interest in vehicle safety and many of the larger manufacturers are pursuing full safety certification of their vehicles. Component specifications are needed or desirable in some instances, especially with regard to charging equipment, crashworthiness, and safety systems to prevent operators or maintenance personnel from contacting conducting surfaces (McCoy, 1993).

6.3.3.5 Utility Impacts

To be prepared for increasing numbers of EVs dependent upon the local electric system, electric companies need to project the system impact of various levels of EV introduction under a range of charging scenarios. Utilities can then make business decisions which will have an important affect on EV charging infrastructure and life-cycle costs. For example, utilities may structure their rates to encourage EV charging during low load periods, such as midnight to 5 o'clock in the morning.[3] Utilities may decide to incentivize EV purchase and/or assist in the build-up of recharging infrastructure in order to improve electricity demand

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[3] As described earlier, the Hawaiian Electric Company, Inc. (HECO) is interested in EVs as a way to increase the nighttime load.

curves. Also to try to flatten the load curve, utilities may develop smart control systems or solar-powered charging stations.

California utilities are preparing for the California Air Resources Board (CARB)-mandated EV sales in California beginning in 1998. Southern California Edison (SCE), which provides about 60 percent of Southern California's electricity, has performed several studies of the impact of EVs on their system. In general SCE has found that, under several scenarios, EV deployment would allow a reduction in SCE's electric rate, on the order of a few percent. For scenarios which assume advanced batteries, SCE projects that EV charging will have little impact on peak loads, whereas substantial deployment of EVs with current battery technology (and thus more opportunity charging) would significantly increase peak loads. Another interesting point that SCE makes is that simple financial incentives to encourage nighttime charging may actually worsen the demand curve under the advanced battery scenario (see Figure 6-3). This happens because charging times are assumed to typically start in the early evening and continue for only three hours or less. A much flatter load curve may be assumed with a "smart control" system (see Figure 6-4). A smart control system would determine the battery depth of discharge, calculate charging time, and delay charging of certain percentages of the EVs to the early morning hours, optimizing the load curve. Such a control system would have to take into account the month-by-month change in the demand curve, as well (Ford Motor Company, 1992).

6.3.4 PROPANE

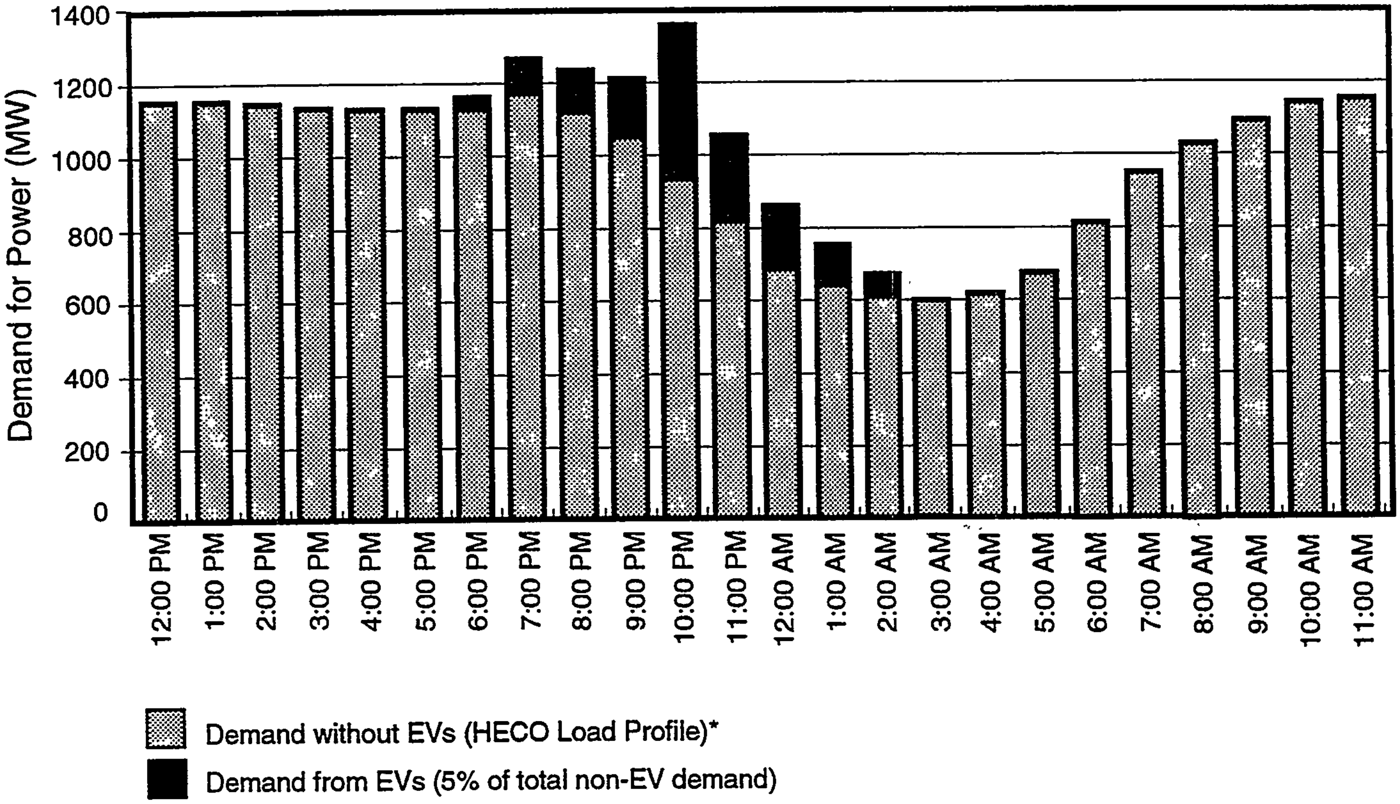
The most important consideration in installing propane infrastructure is fire safety as propane is highly flammable. This is of great concern in the event of a leak as propane is heavier than air and will therefore pool in low spots creating a substantial fire hazard. Because propane is perhaps more of a fire hazard than any other motor vehicle fuel, propane refueling in Hawaii can only be performed by trained personnel (Kepoo, 1994).

As stated above for alcohol fuels, propane should be properly stored and transported and fire suppression systems should be installed as appropriate. Codes, standards, and recommended practices should be followed, and personnel should be trained in propane handling. Local fire departments should be aware of the location of all propane facilities and should be prepared to handle propane fires.

Propane has been used as a commercial motor vehicle fuel for over 60 years and propane storage, distribution, and vehicle refueling technologies, codes, and standards are established. As described above, many propane vehicle refueling stations are operating in Hawaii already, and the capacity exists to increase propane distribution.

Figure 6-3

Standard Nighttime Charging

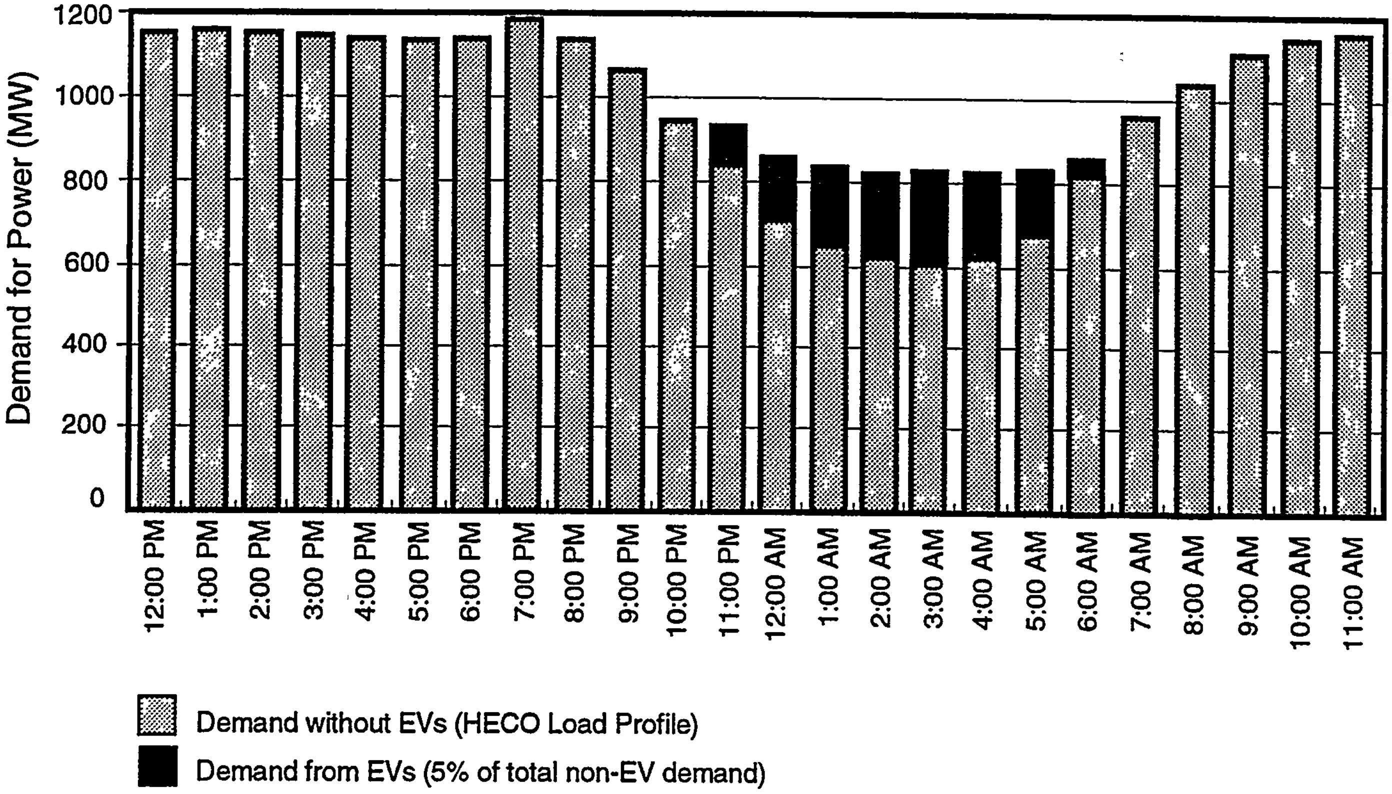


*HECO Profile: Peak demand day in 1994 (9/19/94)

Source: Personal communication, Alan Lloyd, 2/5/95

Figure 6-4

"Smart" Nighttime Charging



6.4 CONCLUSION: IMPLICATIONS OF ALTERNATIVE FUEL PROGRAMS FOR FUEL-RELATED INFRASTRUCTURE

Storing, distributing, and marketing biodiesel and propane for use in motor vehicles in Hawaii will be relatively uncomplicated. Biodiesel blends can use the existing diesel infrastructure, provided care is taken to ensure that seals and other components which may be made of rubber are compatible with biodiesel. Low-level alcohol blends may use the existing gasoline retail infrastructure, although bulk storage for the alcohol at the blending terminal would be needed. The necessary propane infrastructure already exists and can be expanded as needed.

Infrastructure for neat alcohols and high-level alcohol blends is not in place and alcohol fuel use will require properly engineered (or modified) bulk storage facilities and refueling station systems, as well as appropriate methods of truck and barge transfer of the alcohol fuel.

EV infrastructure is in place in the sense that electric utilities serve the islands, and most people have electricity service. However, the special considerations described above remain to be addressed in Hawaii and in the nation. Chapter 10 explores policies and incentives which could help build up EV-related infrastructure.

CHAPTER 7

INDIGENOUS BIOMASS ENERGY SOURCES

7.1 PRESENT BIOMASS AND BIOENERGY PRODUCTION

This Section discusses existing biomass production and conversion in the state.

7.1.1 LOCATION, TYPE, AND YIELD OF AGRICULTURAL CROPS AND RESIDUES

Crops assessed in this investigation include sugarcane, pineapple, macadamia nuts, other fruits, field crops, grazing crops, coffee, aquaculture, and forest. Of these, only crops that are produced in substantial quantities and yield significant residues that are presently being used for energy or potentially could be used for energy are discussed here. Since municipal solid wastes (MSW) and animal wastes represent significant sources of energy that can have sizable disposal costs that might serve as credits (via "tipping fees") to offset collection and processing costs, they are logical candidates for energy production (and in some cases already are being used successfully) and therefore are inventoried along with crops and crop residues. The amounts of major biomass residues and their energy value are summarized in Table 7-1. The total amount of residues produced in the state is 3.8 million tons per year.

Sugarcane residues, comprised of bagasse (milled sugarcane fiber, which presently is being almost fully utilized, although often at less than optimal efficiency) and "cane trash" (mostly extraneous material, burned in the field), represent by far the largest resource. In 1991, 1.7 million tons of sugarcane residues was available in the field. Studies (e.g., Kinoshita, 1988) suggest that approximately 35 percent of the fiber in standing sugarcane is consumed in open-field burning of cane, leaving only about 1.1 million tons of fiber (in bagasse) at the factory, nearly all of which is used as boiler fuel. Municipal solid waste (also already being utilized to a large extent for energy purposes), at 1.2 million tons per year with approximately 65% organic content (McCabe, 1994), represents the state's second largest biomass residue resource. The energy contributions of other crop residues and animal wastes are relatively modest.

In total, the energy value of all biomass residues presently being produced in the state is less than 0.04 quad. While this is a substantial amount of energy, it represents only approximately 10 percent of the energy presently consumed in the state, and to a large extent already is being converted, mostly into electricity. Thus, if biomass is to displace a major portion of the fossil fuels imported into the state, the resource tapped would have to be dedicated feedstocks produced specifically for energy conversion rather than crop residues.

7.1.2 PRESENT USE OF CROPS AND RESIDUES

Disposition of the above mentioned biomass residues is summarized in Figure 7-1. Except for sugarcane and municipal solid wastes, biomass residues are not used extensively for conversion purposes. For example, most of the pineapple residue after harvesting is burned

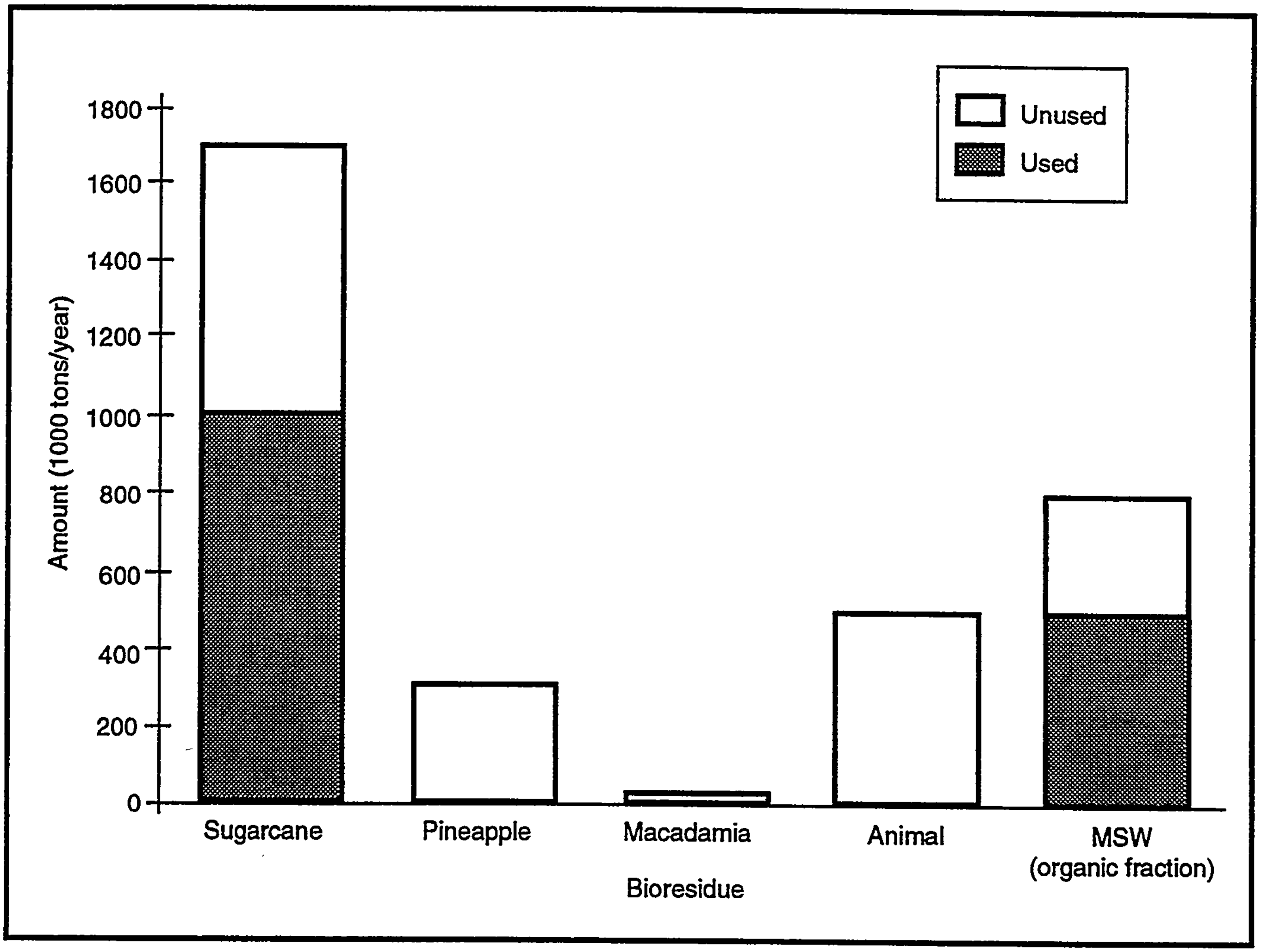
Table 7-1

Amount and Energy Value of Biomass Residues Produced in Hawaii, 1991

Biomass Resource	Annual Output (1,000 tons)	Energy Potential (1,000 joules/yr)	(%)
Sugarcane residues	1,696	29,036	67
Pineapple residues	313	4,891	11
Macadamia nut hulls	14	230	1
Animal wastes	505	512	1
Municipal solid waste	1,242	8,583	20
Total	3,770	43,252	100

Figure 7-1

Disposition of Biomass Residues in Hawaii, 1991
(All Tonnages Are Given on Dry Bases Except for MSW and Animal Wastes)



in the field or plowed under; and only a portion of macadamia residues are used for process heat.

7.1.3 EXISTING BIOMASS-FOR-ENERGY (FUEL OR ELECTRICITY) CONVERSION FACILITIES

Biomass makes a far greater contribution in serving the energy requirements of the state than any other non-fossil resource in Hawaii. Most of the biomass conversion facilities in the state are cogeneration facilities that produce process heat and electricity. A graphical database (see Appendix A-5) contains details on the various biomass-for-energy conversion facilities in the state.

The sugar industry is the largest converter and user of biomass energy in the state. In 1991, approximately one million tons of sugarcane bagasse (dry basis), having an energy value of $17x10^{12}$ British termal units (Btu), was consumed in sugar factory cogeneration plants. The gross amount of electricity attributable to that quantity of bagasse was approximately 500,000 MWh, and, considering the very efficient manner in which heat is used in processing cane into sugar (including, for example, the use of multiple-effect evaporators and extracted steam for mechanical drives), the amount of process energy attributable to that bagasse is exceedingly high. The difference between the amount of bagasse consumed (approximately 1 million tons, dry basis) and the amount of sugarcane residue actually produced (1.7 million tons, Figure 7-1) is attributable to sugarcane fiber consumed in open-field burning of cane and in fiber used for other purposes.

A large converter of non-crop-related biomass into marketable energy in the state is the "Honolulu Project of Waste Energy Recovery" (H-POWER) MSW conversion plant on Oahu. In 1991, more than 600,000 tons of MSW (roughly one-half of the 1,200,000 tons produced in the state) was processed by H-POWER, with most of the MSW being converted into refused-derived fuels (RDF) and then into 370,000 MWh (gross generation; net sale to the utility company was 320,000 MWh) of electricity.

Another significant non-crop-related biomass-for-energy project in the state is the Kapa'a Generating Partners' sanitary landfill gas recovery project, which taps 2.3 million cubic feet of gas generated daily in an 85 acre landfill in Kailua, Oahu, and, in doing so, generates process heat and 10,000 MWh (1993) of electricity via a 3.2 MW gas turbine generator.

One biomass-for-energy conversion pilot project of potentially major significance, presently under construction, is the biomass gasifier scale-up facility at the Paia sugar mill on Maui (Overend et. al., 1992). That project, funded primarily by the U.S. Department of Energy and the State of Hawaii, seeks to scale-up biomass gasification technology with the goal of using that technology for the production of electrical power and transportation fuels. The first phase, underway, calls for designing, constructing, and operating a scaled-up biomass gasification plant; assessing environmental impact; and developing a centerpiece for continuing research on biomass gasification and for evaluating commercial applications for the product gas. Follow-on phases in this program include upgrading the product gas for use in a gas turbine-electrical generator (Phase 2) and for catalytic conversion into a liquid transportation fuel (Phase 3). The Maui biomass gasifier facility presently is intended to process 50 tons (dry basis) per day of biomass. During the next phases of development, it will be modified to process 100 tons per day.

The other biomass conversion plants in the state are much smaller in scale than those mentioned above and are not discussed here.

7.2 POTENTIAL BIOENERGY PRODUCTION

7.2.1 ENERGY CROPS

7.2.1.1 Candidate Energy Crops

The species of plant selected for conversion into transportation fuels would depend on its suitability to local conditions, yield, cost of production and delivery, type of transportation fuel to be produced, and conversion technology to be employed. Sugarcane grown commercially in Hawaii is one of the best crops in producing biomass dry matter, and has advantages over most other energy-crop candidates, including well developed infrastructure, cultivation and harvesting technologies. Moreover, it is likely that if sugarcane cultivars and agronomic practices were adopted to maximize biomass yield rather than sugar yield, significantly higher biomass productivities could be obtained (Osgood and Dudley, 1993). Owing to the high yield and yield potential of sugarcane, and its existing infrastructure and inherent advantages in producing fermentation products such as fuel ethanol, sugarcane is one of the obvious energy crop candidates considered in this investigation.

Several high-fiber-yielding tree and grass species have been considered as possible short-rotation, intensive-culture (SRIC) energy-crop alternatives to sugarcane. Although some of these alternative crops have yield potentials that might exceed that of sugarcane, experience in growing and harvesting most of these alternative crops in Hawaii generally is less extensive than with sugarcane. Also, because these crops produce essentially only fiber, they may not offer the same opportunities or productivities for fermentation products as would sugar-bearing crops such as sugarcane.

One of the critical factors impacting the economic viability of biomass-for-energy is the yield potential of a crop species under optimum cultivation practices. Numerous biomass experiments have been performed in Hawaii which have identified a number of promising high-yielding species of trees and grasses. Most of those species have the potential to be refined into energy, fiber, or chemical products. Because of their high yields and versatility, *Eucalyptus* and *Leucaena* offer the best commercial potential of the tree species. Napiergrass (*Pennisetum purpureum*) has been found to have the greatest yield potential and the strongest commercial potential of the grass species.

The grass and tree crop yields used in this study were projected from experiments conducted by the Hawaiian Sugar Planters' Association at Hoolehua, Molokai and elsewhere in the state.

At Hoolehua, seven crops (one plant crop and six ratoon crops[1]) of banagrass (a variety of Napiergrass) were harvested over a 4.3 year period. Yield results are presented in Table 7-2. The cumulative dry-matter yield over the seven crops was 84 tons per acre, giving an average yield of 19.8 tons per acre-year.

Ratoon crops of banagrass yielded more than twice the plant crops in another Hawaiian Sugar Planters' Association study which included five locations (Table 7-3). Fiber content in the ratoons was 29.6 percent, whereas plant crops contained only 18.9 percent fiber. The average yield for plant crops was 18.5 tons per acre-year; by contrast, the ratoon crops averaged 42.1 tons per acre-year.

Two tree yield experiments were conducted on Molokai by the Hawaiian Sugar Planters' Association. Tree height and diameter were measured in a two-year study at Hoolehua, Molokai. Tree yield was estimated based on the height and diameter. The dry matter yield for *Leucaena* "K636" planted at 1 meter by 1 meter spacings, 4,000 trees per acre (10,000 trees per hectare), was 9.3 tons per acre-year. A five-year study involving wider spacings, 2 meters by 2 meters, 1,000 trees per acre (2,500 trees per ha), was also conducted with *Leucaena* "K636," which gave a yield of 8.6 tons per acre-year. Another five-year study on Maui with the same species produced 8.4 tons per acre-year.

The yield of banagrass was about twice the yield of *Leucaena* in the Hawaiian Sugar Planters' Association Molokai studies; however, the banagrass was harvested seven times while the *Leucaena* was harvested only once. More frequent harvests of *Leucaena* probably would have resulted in higher yields but with higher moisture content.

The growth of *Eucalyptus* and *Leucaena* from seedling populations have been highly variable in growth rate and form. The selection of superior trees and the development of their clones offers a potential method of rapidly increasing productivity and uniformity of biomass plantations. Clonal plantations of *Eucalyptus grandis* have been established in Brazil, Africa, India, and California. In Brazil, Aracruz Florestal has nearly doubled its yields by using selected clones instead of unimproved seedling stock. A *Leucaena* breeding program, designed for maximum biomass productivity, might be able to provide incremental gains of 5-10 percent per generation.

7.2.1.2 Land Availability And Suitability

7.2.1.2.1 Land Availability

In this section, land availability refers to the relative accessibility of land for energy cropping from the legal standpoint. The availability of land for biomass-for-energy production in the state is dictated primarily by zoning. However, the actual use of agricultural land and the ownership of land can provide insight on whether the land might be immediately available for biomass-for-energy production and on potential barriers preventing its use for such purposes; therefore, present use and ownership of land also are discussed here.

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[1] A ratoon crop is produced by using the stalk or shoot arising from the root or crown of a perennial plant.

Table 7-2

Banagrass Yields (Dry Matter) at Hoolehua, Molokai

Harvest Number	Harvest Date	Crop Days	Yield[1] (Tons/Acre)	Dry Matter[1] (Tons/Acre Year)	Season
1	4/20/87	217	6.87	11.55	Winter
2	11/8/87	212	15.8	27.21	Summer
3	5/24/88	188	9.69	18.81	Winter
4	2/22/89	289	15.83	20.35	Winter
5	8/23/89	176	15.1	31.32	Summer
6	4/3/90	223	8.87	14.51	Winter
7	1/8/91	280	11.61	15.13	Winter
Average		226.43	11.97	19.84	

Source: Hawaiian Sugar Planters' Association data

Note:

1) Plots of 40 feet x 40 feet were hand harvested. Three replications were harvested at each date from a 0.7-acre planting.

Table 7-3

Dry Matter Yields of Plant Versus Ratoon Crops for Banagrass at Five Locations in Hawaii

Location	Yield (Tons/Acre)		Yield (Tons/Acre-Year)	
	Plant	Ratoon	Plant	Ratoon
Mauna Kea Agribusiness Co.	12.91	36.14	18.84	47.52
HC&S Co.	10.09	31.61	17.04	41.64
McBryde Sugar Co.	8.39	29.62	15.24	32.04
The Lihue Plantation Co.	9.56	39.35	17.4	42.48
Waialua Sugar Co.	12.05	35.32	24.12	47.04
Average	10.6	34.41	18.53	42.14

Source: Hawaiian Sugar Planters' Association data.

Zoning

The six largest islands in the state (Hawaii, Maui, Oahu, Kauai, Molokai, and Lanai) cover 4.0 million acres (1.6 million hectares) with diverse geographical and environmental characteristics. Hawaii is the only state in the nation with statewide land-use designations; these include: Conservation, Agricultural, Urban, or Rural, as determined by an appointed Land Use Commission.

The graphic database (Appendix A-5) presents detailed maps showing the land designations for the six major islands. Table 7-4 summarizes the land designations for the four counties and the entire state. Only lands classified as Agricultural or Conservation are considered as potentially available for energy crop production (although practically speaking, a large fraction of the land designated Conservation would not be available for crop production owing to environmental and cultural concerns). Conservation and Agricultural lands represent the two largest land designations in the state, comprising 2,000,000 and 1,900,000 acres (800,000 and 760,000 hectares), or 49 percent and 46 percent, respectively, of the total land area.

The island of Hawaii, with 1,200,000 acres (490,000 hectares) of Agricultural land, has nearly twice as much land zoned Agricultural as the remainder of the state combined. Maui, with nearly 250,000 acres (100,000 hectares), has the second largest acreage zoned Agricultural; Kauai, Oahu, and Molokai have about 120,000 acres (50,000 hectares) each zoned Agricultural; and Lanai has less than 50,000 acres (20,000 hectares) of Agricultural land. Each of the four counties regulates Agricultural lands under guidelines established by the Land Use Commission.

Urban and Rural lands comprise only 180,000 and 10,000 acres (73,000 and 4,000 hectares), respectively, about 4 percent and less than 1 percent of the total land area in the State of Hawaii.

Land Use

Appendix A-5 presents detailed maps showing recent uses of agricultural lands for the six major islands. Utilization of agricultural lands in the four counties in the state, summarized in Table 7-5, is categorized as follows (in order of descending acreage): sugarcane, pineapple, macadamia nuts, fruits and vegetables, miscellaneous crops, and coffee.

Only those agricultural uses with agronomic needs that are comparable to energy crops (e.g., intensively cultivated crops) should be considered. Some lands that are not under intensive culture, such as pasture land, often are not well suited for energy crop production because factors needed for high yield (e.g., irrigation water, terrain compatible with mechanization) might not be available.

Table 7-4

Summary of Land Designations in the State, 1991
Zoning - State of Hawaii

Zone	Land Area (1,000 acres)				
	Hawaii	Kauai[1]	Maui[2]	Oahu	Statewide
Agriculture	1,199	147	401	131	1,878
Conservation	1,333	195	296	156	1,980
Rural	1	1	8	0	11
Urban	48	13	21	96	179
Total	2,581	356	726	383	4,048

Notes:
1) The county of Kauai comprises the islands of Kauai and Niihau.
2) The county of Maui comprises the islands of Maui, Molokai, and Lanai.

Table 7-5

Summary of Present use of Agricultural Lands in the State, 1991
Usage - State of Hawaii

Crop	Land Area (1,000 acres)				
	Hawaii	Kauai[1]	Maui[2]	Oahu	Statewide
Sugarcane	56	34	43	23	156
Pineapple			16	13	29
Fruits and Vegetables	7	1	3	2	13
Macadamia nuts[3]					2
Coffee[4]					23
Miscellaneous	2	1	2	1	6

Notes:
1) The county of Kauai comprises the islands of Kauai and Niihau.
2) The county of Maui comprises the islands of Maui, Molokai, and Lanai.
3) Data for macadamia nuts reported separately for each county; only statewide total reported.
4) Data for coffee not reported for each county; only statewide total, excluding Kauai acreage, reported.

Ownership

Land ownership does not directly determine whether a parcel of land is available for energy crop production. However, land ownership can pose restrictions on the timing in which a targeted parcel of land becomes available and the specific use of that land; therefore, land ownership is examined in this investigation. The information is summarized in Table 7-6.

Table 7-6

Summary of Land Ownership in the State, 1991

Ownership	Land Area (1,000 acres)				
	Hawaii	**Kauai**[1]	**Maui**[2]	**Oahu**	**Statewide**
State	941	137	179	54	1,311
HHC[3]	109	19	55	3	187
Federal	223	3	29	52	306
Private	1,308	197	464	275	2,243
Total	2,581	356	727	384	4,047

Notes:
1) The county of Kauai is comprised of the islands of Kauai and Niihau.
2) The county of Maui is comprised of the islands of Maui, Molokai, and Lanai.
3) Hawaiian Homes Commission

Approximately 2,200,000 acres (910,000 hectares), or 55 percent of the land in the state, is privately owned. The majority of the remaining land, 1,300,000 acres (530,000 hectares), about 32 percent of the total area, is controlled by the state; most of state-owned lands are designated Conservation. The Hawaiian Homes Commission (HHC) controls 190,000 acres (76,000 hectares) of land, about 5 percent of the total area. Hawaiian Homes Commission lands are designated Agricultural. The federal government controls over 300,000 acres (120,000 hectares) of land, about 8 percent of the total area, in the state.

Most of the land owned by major landholders in the state is designated Agricultural. While all lands that are designated Agricultural can conceivably be used for energy crop production, much of the lands owned by the various governmental agencies and not presently being used for agriculture would probably not be available. The lands owned by the federal government are mostly being used as national parks, wildlife refuges or by the military, and therefore would not be available. Similarly, much of the lands owned by the state and presently not in agriculture would probably not be available for energy crop production; and a large portion of the county-owned lands are being used for parks and watersheds, and therefore would not be available for energy crop production.

Land Availability Estimation

A methodology for evaluating land availability was developed featuring a classification of five levels of land-use sensitivity (Singh et. al., 1993) varying from Unavailable to Available for crop production. Potential energy-crop lands on four of the five largest islands (excluding Oahu) have been assessed (Phillips et. al., 1992) assuming that only those lands classified as Probably Available (probably available in part, but with concerns in specific areas) or Available (no concerns identified) would be accessible for energy-crop production. The results of this assessment are summarized in Table 7-7.

Table 7-7

Lands Identified as Probably Available and Available for Crop Production on the Islands of Hawaii, Kauai, Maui, and Molokai

Island	Probably Available (Acres)	Available (Acres)	Total (Acres)
Hawaii	368,434	799,386	1,167,820
Kauai	61,776	107,738	169,514
Maui	56,587	214,982	271,569
Molokai	4,201	81,051	85,251
Total for four islands	490,998	1,203,156	1,694,154

Source: Phillips, et.al., 1992

For the islands of Hawaii, Kauai, Maui, and Molokai, the amounts of land considered Probably Available and Available for energy crop production equal 490,000 acres and 1,200,000 acres, respectively, giving a total of 1,690,000 acres. If the land available on Oahu and Lanai are included, it appears that roughly two million acres would be available for energy crop production.

7.2.1.2.2 Land Suitability

Land suitability refers to the ability of a given site to support the production of an energy crop species in a sustainable manner (while economics ultimately determine whether a certain tract of land would be suitable for energy crop production, economic feasibility has not been considered in this assessment of land suitability). The feasibility of short-rotation intensive-culture energy crop production depends largely on the types and amounts of agronomic inputs needed to attain a targeted yield; these are very site specific. Those agronomic factors that determine the suitability of a certain parcel of land to produce energy crops include terrain (elevation and slope), climatic conditions (temperature, rainfall, and insolation), soil characteristics, availability of water, and the like; these are discussed below.

Elevation

Appendix A-5 contains detailed maps showing land elevation for the six major islands. The landscape in the state can be classified into three broad categories: (1) low-elevation lands having altitudes below 500 feet; (2) mid-elevation lands having altitudes between 500 and 1000 feet; and (3) mountains above 1000 feet. Prime agricultural lands generally are found at lower elevations, below 1000 feet, and have rather gentle terrain to facilitate mechanized cultivation and harvesting of crops. Higher elevation lands generally are not good for agriculture, and often are not available for that purpose since they generally are classified Conservation.

Climatic Conditions

Appendix A-5 contains detailed maps showing annual mean temperature, rainfall, and insolation for the six major islands.

The annual mean temperature on Kauai, Oahu, Molokai, and Lanai ranges from 56-77°F; for Maui and Hawaii, with very high elevations, the mean ranges from 44-78°F and less than 40-76°F, respectively. For the six major islands, most locations, other than the mountains, have fairly uniform temperatures, 66-77°F. The agricultural regions on the four lower-elevation islands have temperatures of 62-77°F, and for Maui and Hawaii, those regions have ranges of 60-78°F and 52-76°F, respectively .

Except on the island of Hawaii (along the Hilo-Hamakua coast) and parts of Kauai, most of the prime agricultural lands (i.e., lands presently supporting intensive agriculture) are arid or semi-arid, receiving less than 50 inches of rainfall annually. Regions receiving more than or equal to 100 inches annually largely are classified Conservation. High-yielding energy crops grown in the state would require approximately 100 inches of water annually; therefore, irrigation would be necessary in almost any large-scale commercial biomass-for-energy operation except along the northeastern section (the Hilo/Hamakua coast) and portions of the Puna and Ka'u districts of Hawaii, and smaller contiguous sections on Maui, Oahu, and Kauai.

Insolation in the state ranges from 270-540 langleys (cal/cm2-day). Most of the prime agricultural regions receive high rates of insolation, greater than or equal to 450 langleys; these regions largely coincide with those lands that receive less than 50 inches of rainfall annually. High insolation translates to high yield in energy crops; however, most crops would require some irrigation due to insufficient rainfall in sunny locations.

Soil

Appendix A-5 contains detailed maps showing soil orders on the six major islands.

Ten different soil orders are present in the Hawaiian Islands: (1) Spodosols, (2) Oxisols, (3) Aridisols, (4) Ultisols, (5) Mollisols, (6) Inceptisols, (7) Entisols, (8) Histosols, (9) Vertisols, and (10) Alfisols; much of the mountain regions of each island falls into the category Miscellaneous Land Types. The majority of the lower elevation land mass for the islands of Kauai, Oahu, Molokai, and Maui falls into seven or eight of the above soil orders. For the island of Lanai, only six of these soil orders are present at lower elevations, and for Hawaii, only five (USDA SCS, 1972).

For all major islands except Oahu and Hawaii, most of the lands zoned Agricultural and presently or historically in cultivation contain soils of the Oxisols, Mollisols, Inceptisols and Entisols orders. For Oahu, such lands contain Oxisols, Mollisols, Inceptisols, and Alfisols. For Hawaii, those lands contain Mollisols, Inceptisols, Histosols, and Aridisols (Oxisols are lacking).

The lands covered by Spodosols, Aridisols, and Miscellaneous Land Types generally are considered poor for agriculture. Inceptisols, Entisols, Alfisols, and Ultisols are good for biomass production; the best soils for biomass production are Oxisols and Mollisols. Histosols are organic soils.

Miscellaneous Land Types generally are covered by materials that cannot be classified as soils (e.g., by materials such as rocks or stones, or recently deposited materials). Aridisols are desert soils with very low moisture and organic matter contents. Aridisols often occur in narrow belts along the leeward coast of islands; accumulation of salts in the soil might make these soils problematic for biomass production.

Inceptisols are young soils deficient in phosphorus and thus require relatively high fertilization for high crop yield. Such soils have high infiltration rates, and erosion would be slight to moderate, depending on the degree of slope. Inceptisols are found in abundance on most islands. Although Entisols are not ideal for biomass production, they are used in cultivation of sugarcane and vegetables, and for pasture in Hawaii. Ultisols are highly weathered soils with low to moderate natural fertility, but are very responsive to soil management. These soils are very stable and have good water infiltration rates; leaching of soluble nutrients is likely. Entisols and Ultisols are abundant on Kauai, Molokai, Maui, and Lanai.

Oxisols are the most weathered soil, with very high clay content (up to 90 percent in Hawaii). This soil type covers large areas on all islands, except Hawaii. When properly managed, Oxisols are highly productive. Oxisols have high permeability and leaching of soluble plant nutrients, and moderate water retention.

Mollisols are dark-colored, base rich mineral soils, relatively high in organic matter. Mollisols are excellent agricultural soils with natural fertility (although this varies according to weather conditions). Mollisols are found in quantity on all islands.

7.2.1.3 Potential Lands For Bioenergy Production

The identification of land that might potentially be used for energy crop production is largely an academic exercise. Indeed, much of the 3.9 million acres (1.6 million hectares) of land presently zoned Agricultural or Conservation (note, one-half of this land mass would be nearly two million acres, which would roughly match the acreage deemed "Available" in Section 7.2.1.2.1, with Oahu land included) could be used for the cultivation of energy crops if economic, political, social, and environmental conditions were favorable. This potentially could supply the 0.3 quad (1 quad = 10^{15} Btu or 10^{18} J) of energy presently consumed in the state for transportation and electricity (Department of Business, Economic Development and Tourism, 1994). (A conservative estimate of the energy potential of energy crops from two million acres of land deemed available might assume a yield of 10 tons of dry matter per acre per year with an energy value of greater than 16 million Btu per ton.) However, it is not very likely that the proper conditions that would allow for the conversion of such large acreages will ever exist in Hawaii, just as, even in the most profitable years for sugarcane and pineapple, such large acreages never were placed in cultivation for a variety of reasons, the greatest being economic.

Assuming that those economic factors that prevented certain lands from being placed in intensive agriculture in the past would similarly prevent the same lands from being cultivated in energy crops, the focus of this investigation centers on those lands that presently or in recent history have been in intensive agriculture.

Since this study is interested primarily in energy crops, only those agricultural uses that have similar agronomic needs as energy crops are considered here (e.g., intensively cultivated crops are considered, whereas pasture land is not considered). The amount of land in intensively grown crops has varied substantially over this century; however, the trend generally has been downward. The number of acres in sugarcane, pineapple, and other crops reached a maximum in the 1930s (sugarcane acreage reached a maximum in 1933: 255,000 acres; in 1930, the land area in sugarcane, pineapple, coffee, and other crops was 352,000 acres). However, the amount of land in intensive cultivation 60 years ago probably has little relevance to the amount of land presently available for energy crop production; therefore, the amount of land in intensive cultivation in more recent history (over the last 25 years) is the focus of this investigation.

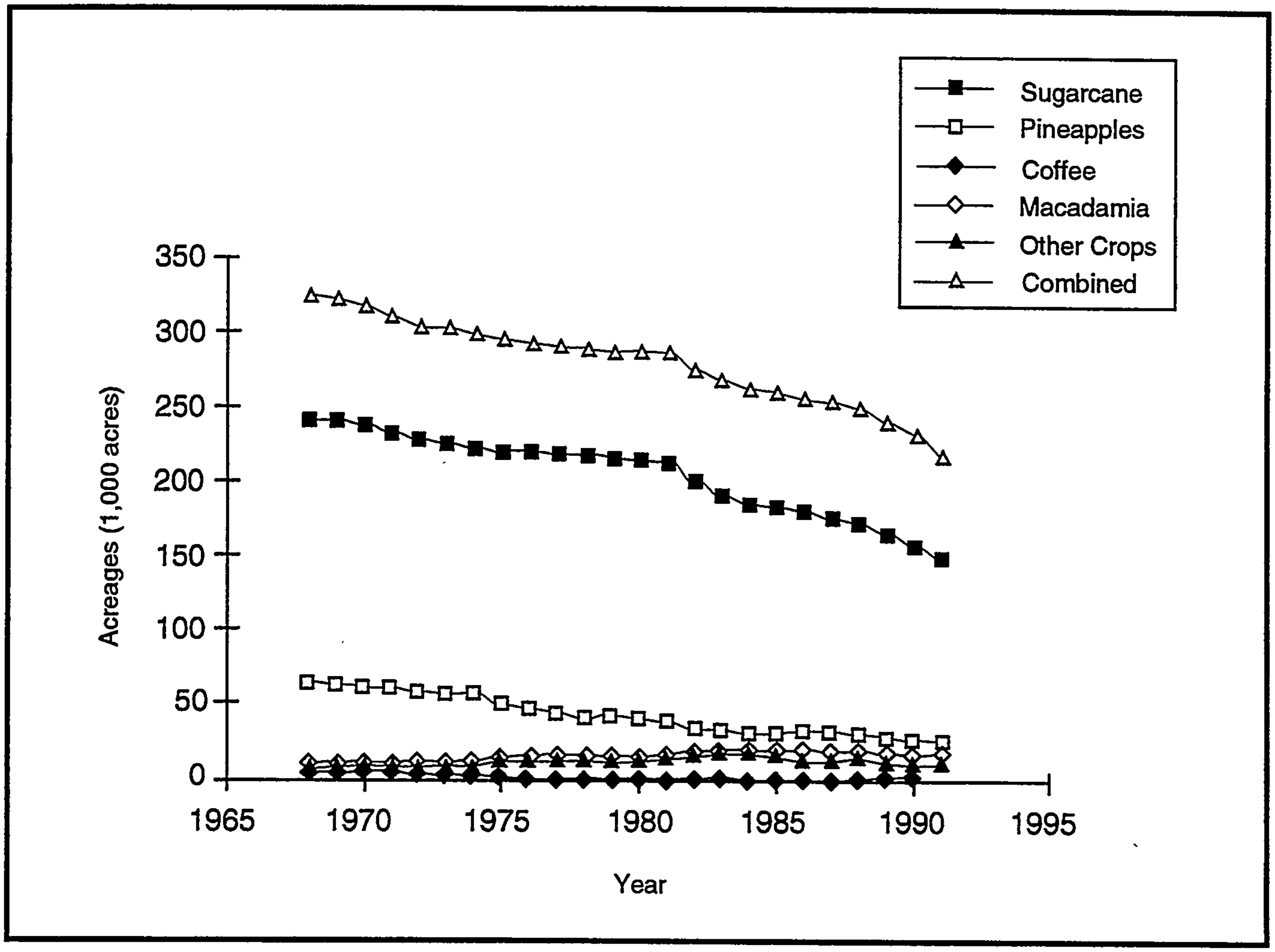
In 1968, the acreages in sugarcane and in all crops combined reached a local maximum, 242,000 acres and 326,000 acres, respectively. Over the last 25 years, the amount of land in agriculture has decreased steadily, owing to substantial reductions in sugarcane and pineapple acreages (Figure 7-2), from 326,000 acres in 1968 to less than 230,000 acres in 1993. Except for the island of Oahu, only a relatively small fraction of the land taken out of intensive cultivation has been reclassified (even on Oahu, much of the land taken out of sugarcane production over the past 25 years still sits fallow); therefore, the vast majority of the approximately 100,000 acres that has been taken out of agriculture could revert to agriculture if the economics of doing so were favorable (additional large tracts of unfarmed agricultural lands exist which could be used to replace lands switched from agriculture to other uses during the past 25 years).

Figure 7-3 compares lands in agriculture on the major islands in 1968 versus 1991. Over that period, acreage in agriculture declined on all islands; since 1991, additional large declines in sugar acreage have occurred.

Sugarcane represents the most abundant, high-energy-yielding crop in Hawaii and sugarcane production expertise and equipment are available in substantial amounts from the existing sugarcane industry. Therefore, sugarcane should be considered as a potential crop to harvest for production of fuels and electricity. Growing and harvesting high-yielding grasses and trees for conversion to electricity and fuel for transportation is another possible approach.

Figure 7-2

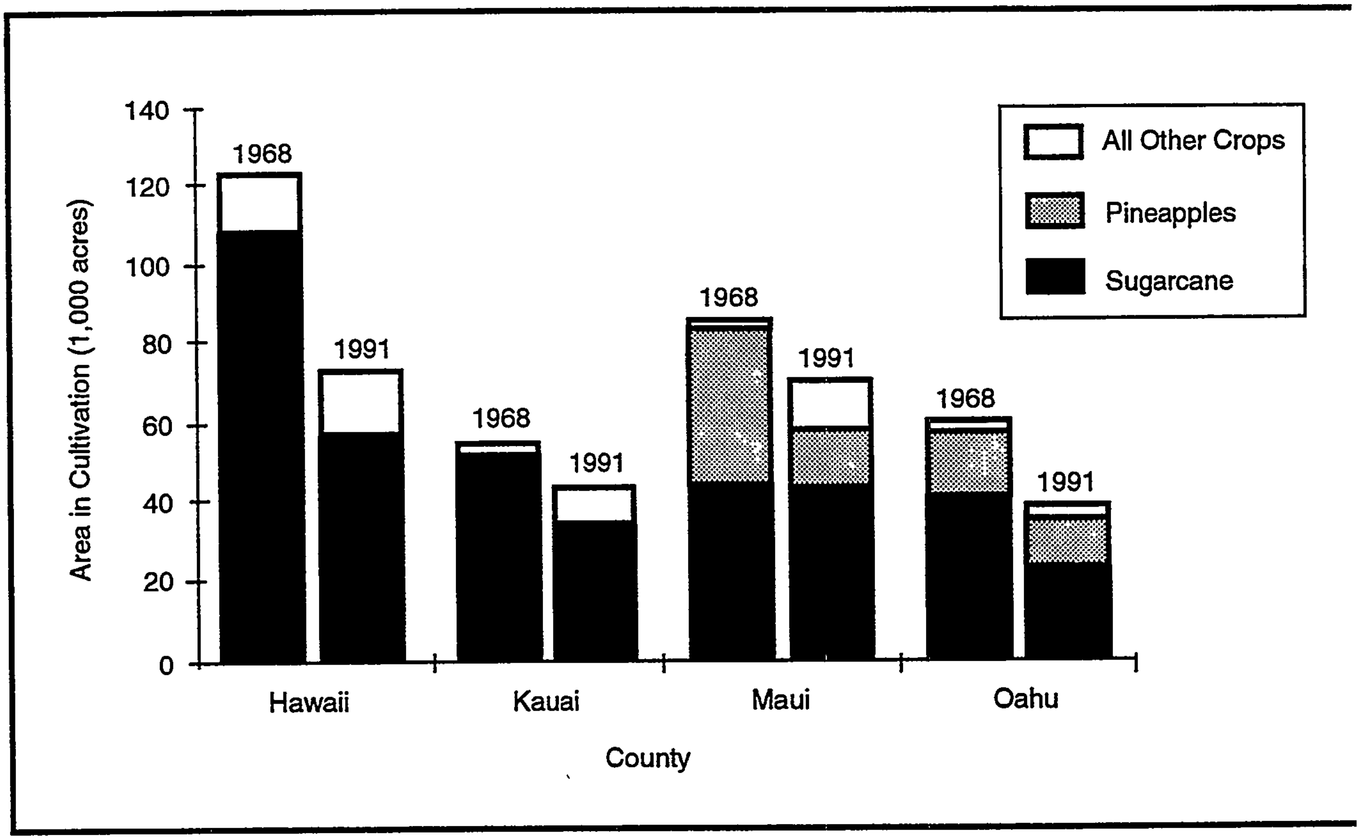
Land in Intensive Agriculture During Past 25 Years



Source: Hawaii Agricultural Statistics Service, various years.

Figure 7-3

Comparison of Acreages in Intensive Agriculture, 1968 versus 1991



Source: Hawaii Agricultural Statistics Service, various years.

Several scenarios for large-scale energy crop production are considered in this investigation:

(a) Use of sugarcane lands (approximately 156,000 acres in 1991) and sugarcane crop to produce fuel and electricity;

(b) Use of only those lands (or equivalent lands) taken out of intensive cultivation during the past 25 years for energy crop production, with the land presently in intensive cultivation remaining in the present crops, thus providing approximately 100,000 acres for energy crop production (the fact that these lands have been taken out of cultivation suggests that they are not as profitable as the lands included in (a), generally having lower yield potential than the above-mentioned parcels.)

(c) Conversion of all lands presently in intensive cultivation to energy crop production, thus providing nearly 230,000 acres for energy crop production (the fact that these lands remain in cultivation while others have been taken out of cultivation, suggests that they are the most profitable, generally having the highest yield potential; although high yielding and profitability are not necessarily synonymous.)

(d) Use of those lands (or equivalent lands) presently and previously (25 years ago) in intensive agriculture, nearly 330,000 acres, for energy crop production (note, while the vast majority of the lands in intensive agriculture during the past 25 years should be able to support the production of short-rotation intensive-culture energy crops, largely because the climatic and agronomic requirements for energy crops would be similar to those for sugarcane, a portion of the targeted lands, e.g., pineapple fields, might not be able to meet the high water demands for energy crops and therefore might not be well suited for the production of energy crops.)

Thus, four scenarios are considered in this investigation; they are summarized in Table 7-8.

Table 7-8

Land-Use Scenarios Considered

Number	Description
1	Use existing sugarcane lands (156,000 acres in 1991) and sugarcane crop to produce ethanol and electricity
2	Use lands equivalent to those lands removed from intensive cultivation since 1968 for energy crops (≈100,000 acres)
3	Convert lands presently in intensive cultivation to energy crops (nearly 230,000 acres)
4	Use lands equivalent to those lands in intensive cultivation in 1968 for energy crops (nearly 330,000 acres)

Considering the large number of workers in agriculture and others in the community who are supported by agriculture, and considering the large acreages of land involved, all of the above-mentioned scenarios could have very serious social and other implications. Furthermore, these scenarios would involve changes in the manner and location of extensive fuel and electricity production facilities for the state, and those changes also could carry serious social and other implications. Measurement of these implications would entail careful and extensive analyses of the various changes resulting plus the social, environmental, and other impacts of these changes; such analyses are clearly outside the scope of this investigation. While such implications could have far greater impact on society than those relating to energy production and use, this investigation focuses primarily on the energy aspects of producing fuels and electricity from biomass.

7.2.1.4 Energy Crop Yields Commercially Achievable

Since the available data on yield versus agronomic conditions (water, nutrients, etc...) are not precise enough to predict yield differences that would result from the small variations in agronomic conditions on the targeted lands, no attempt was made in this investigation to predict energy crop yields on a site-by-site basis.

Calculations performed by Hawaii Natural Energy Institute (HNEI) (Kinoshita, 1984) suggest that sugarcane grown commercially in Hawaii during the late 1970s and early 1980s produced an average dry-matter yield (prior to burning the crop in the field in preparation for harvesting and processing) of 17.5 tons per acre-year, comprising approximately 60 percent fiber and 40 percent sugar. (The yield of unburned sugarcane should not be confused with the commercial dry-matter yield, fiber and sugars, presently being reported by the Hawaiian sugar industry - the latter, the commercial yield, is determined after losses due to field burning and wet cane cleaning are incurred; it is assumed that similar practices would not be employed in the sugarcane-for-fuel option, thereby bringing sugarcane-for-fuel yields much closer to that of unburned cane.)

It appears feasible to achieve commercial yields of 18 to 25 tons per acre-year (dry basis) of banagrass and 9 to 15 tons per acre-year of tree crops if inputs (water and nutrients) are not limiting. (Management will play a major role in the actual yields in any biomass-for-energy operation.)

The commercial yields assumed in the present investigation are: for high-growth-potential regions (traditionally high-yielding areas) - 19 tons per acre-year for sugarcane, 22 tons per acre-year for banagrass, and 12 tons per acre-year for the tree crops; and for medium-growth-potential regions (traditionally lower-yielding areas) - 16 tons per acre-year for sugarcane, 18 tons per acre-year for banagrass, and 10 tons per acre-year for the tree crops. These assumed yields are summarized in Table 7-9.

The tree yields assumed are similar to those projected by many other investigators; e.g., based on ongoing work at BioEnergy Development Corporation on the island of Hawaii, Whitesell et. al. (1992) projected *eucalyptus* yields of 8-12 tons per acre-year for unirrigated sugarcane lands on that island, and in considering *eucalyptus* grown on 85,000 acres covering four islands, Phillips and co-workers (1993) projected harvestable yields of 11.4, 10.0, 10.2, and 9.3 tons per acre-year, for the islands of Hawaii, Kauai, Maui, and Molokai, respectively, averaging 10.2 tons per acre-year.

Table 7-9

Assumed Energy Crop Yields (Tons/Acre-Year, Dry Basis)

Species	High-Growth Potential	Medium-Growth Potential
Sugarcane	19	16
Banagrass	22	18
Trees	12	10

As mentioned earlier, if efforts were made to maximize biomass yield rather than sugar yield, significantly higher biomass productivities with sugarcane appear possible. It is also likely that with aggressive breeding and selection, significantly higher commercial yields of the fiber crops (banagrass and trees) than those assumed in this investigation are achievable. Inherent to these yield projections is the assumption that inputs are not limiting. Indeed, whether sufficient inputs would be provided so that near-maximum yields can be achieved depends on the return farmers receive for the crop versus its cost of production. Cost studies performed by HNEI and coworkers for energy crops on Molokai suggest that if the market for energy crops is pegged at fossil fuel values, the production of intensively grown energy crops would not be feasible under most circumstances.

7.2.1.5 Amount Of Biomass Feedstock Potentially Producible

Based on the land-use scenarios listed in Table 7-8 and on the energy-crop yields listed in Table 7-9, Table 7-10 shows the amount of biomass feedstock that could be produced in the state.

7.2.2 OTHER FEEDSTOCKS

As mentioned in Section 7.2.1, biomass residues other than those from sugarcane or MSW represent a rather small energy resource; therefore, they are eliminated from further discussion. Only about one-half of the 1.2 million tons of MSW produced in the state annually is being converted into electricity; if the organic fractions of that resource were fully utilized, an additional 300,000-400,000 MWh per year of electricity might be producible. MSW is produced in much smaller quantities and is more dispersed on the neighbor islands than on Oahu and is generally handled differently. The feasibility of collecting and converting MSW into electricity in a manner similar to that being performed on Oahu, a topic of frequent study, is unclear. Sugarcane residues presently not used for boiler fuel represents another significant energy resource, approximately 600,000 tons annually. If the residues were recovered instead of burned in the field and then utilized for power generation along with bagasse, an additional 400,000-500,000 MWh of electricity might be producible annually (Kinoshita, 1991).

Table 7-10

Amount and Type of Feedstock Produced for Each Land-Use Scenario

Scenario[1]	Feedstocks Produced Annually[2]
1	830 thousand tons of fermentable sugars and 1.0 million tons of combustible fiber using existing commercial sugarcane crop on 156,000 acres[3]
2	1.6 million tons of sugarcane, 1.8 million tons of banagrass, or 1.0 million tons of tree crops using lands (≈100,000 acres) removed from intensive cultivation since 1968
3	4.3 million tons of sugarcane, 5.0 million tons of banagrass, or 2.7 million tons of tree crops using lands (nearly 230,000 acres) presently in intensive cultivation
4	5.9 million tons of sugarcane, 6.8 million tons of banagrass, or 3.7 million tons of tree crops using lands (nearly 330,000 acres) in intensive cultivation in 1968

Notes:
1) See Table 7-8 for description of land-use scenarios.
2) The nearly 230,000 acres presently in production are assumed to be high yielding while the 100,000 acres taken out of production since 1968 are assumed to be lower yielding (while this is an oversimplification of the yield potential of both tracts of land, the trend at least for sugarcane has been the closing or down-sizing of lower-yielding plantations while higher-yielding plantations have remained more stable.)
3) Sugars and fiber data based on commercial data for 1991 from HSPA (Hawaiian Sugar Planters' Association, 1992).

7.2.3 BIOENERGY CONVERSION TECHNOLOGIES; TRANSPORTATION FUEL AND ELECTRICITY PRODUCTIVITIES

The estimated amount of transportation fuels producible from a unit of biomass varies, depending on the type of fuel produced and the technology employed. The following liquid fuel products and conversion processes are considered in this analysis:

(1) ethanol produced from sugars in sugarcane via fermentation;

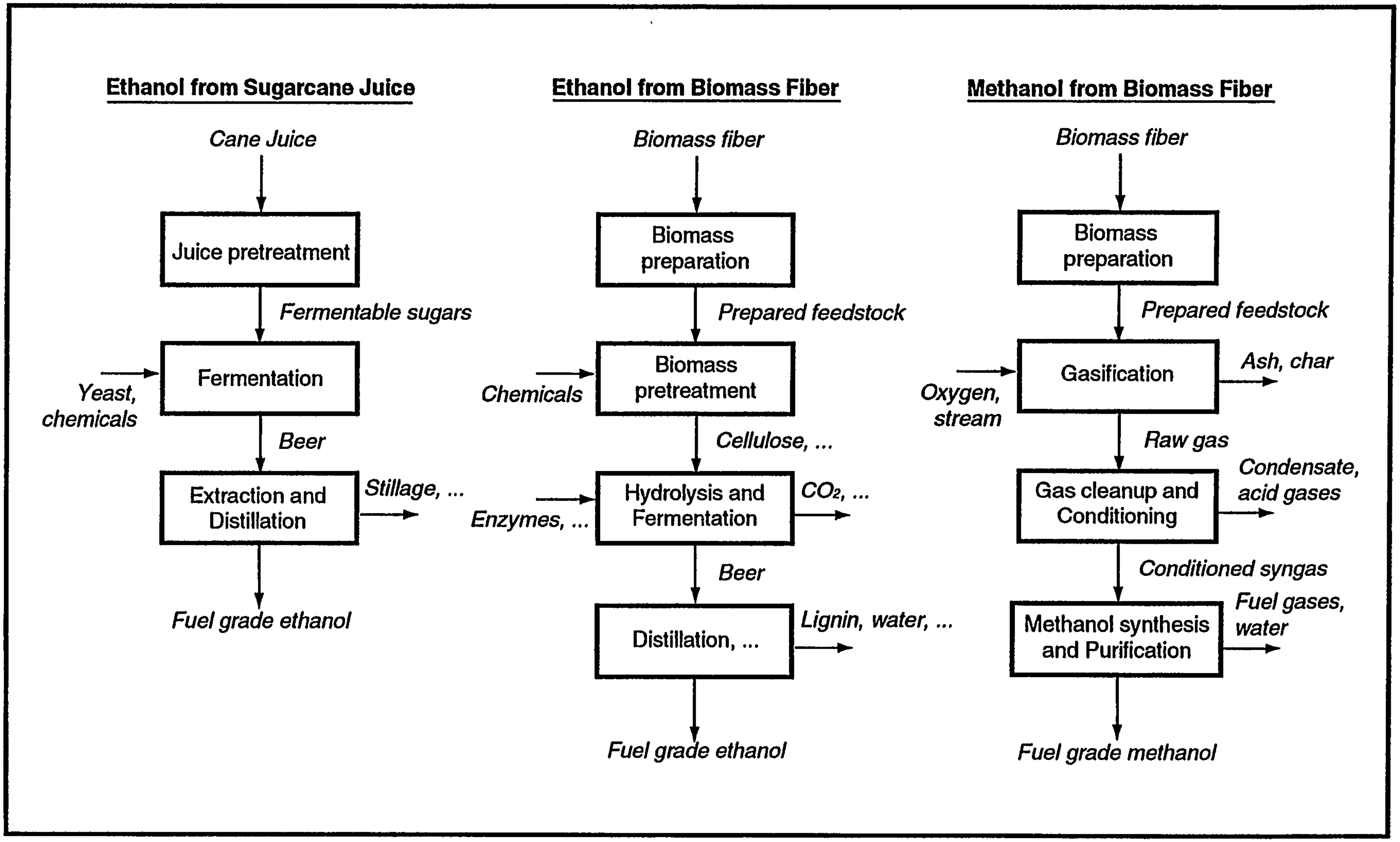
(2) ethanol produced from sugarcane sugars via fermentation and from sugarcane fiber via hydrolysis and fermentation; and

(3) methanol produced from biomass via partial oxidation (gasification) followed by catalytic synthesis (Figure 7-4).

The process of producing ethanol by fermentation of sugars has been well documented and subject to refinement for centuries; the production and utilization of ethanol from sugarcane molasses and other sugars in Hawaii has been the subject of numerous studies (e.g., Department of Business and Economic Development and Hawaiian Sugar Planters'

Figure 7-4

Alternative Biomass-To-Transportation Fuel Conversion Processes



Source: Hawaii Natural Energy Institute, 1994.

Association, 1987). Conversion of fiber into ethanol via hydrolysis and fermentation or into methanol via thermochemical conversion is still in the developmental stage; additional details on such processes are abundant in the literature (e.g., Wyman et. al., 1993; Takahashi, 1989).

The biomass-to-electricity technologies considered include:

(1) medium-pressure (greater than or equal to 800 psi) steam generation systems; and

(2) gas-turbine based combined-cycle systems.

The status of conversion technologies considered and their estimated conversion efficiencies are summarized in Table 7-11

Table 7-11

Status of Technology and Estimated Efficiencies for Selected Biomass-to-Energy Conversion Processes

Process/End Product	**Status**[1]	**Anticipated Yield**[2]
Biomass-to-transportation-fuels[3]		
• Ethanol from sugarcane sugars	Available	143 gal/ton[4]
• Ethanol from sugarcane (hydrolysis/fermentation)	<10 years	110 gal/ton[5]
• Methanol from Fiber (gasification/catalysis)	<10 years	150 gal/ton[6]
Biomass-to-electricity		
• Steam-turbine cycle using fiber	Available	1200 kWh/ton[7]
• Gas-turbine combined cycle using fiber	<10 years	1440 kWh/ton[7]

Notes:

1) Status denotes probable time span required to develop conversion technology to commercial stage.
2) Yield of transportation fuel or electricity per ton of dry matter in feedstock.
3) Does not include electricity-generation component. On basis of lower heating values, fuel equivalency is: 1 gallon gasoline = 1.5 gallons ethanol = 2.0 gallons methanol.
4) Steingass et. al., 1989.
5) Shleser, 1993a.
6) Takahashi, 1989.
7) Net power generation; 1200 kWh/ton = 25% efficiency and 1440 kWh/ton = 30% efficiency (averages of several published and unpublished values).

The data in Table 7-11 suggest that the yields of ethanol from sugarcane (110 gallons per ton dry matter) and methanol from plant fiber (150 gallons per ton dry matter) are comparable on a gasoline-equivalent basis, with both options yielding approximately 75 gasoline-equivalent gallons per ton of feedstock. Thus, the petroleum-displacement potential of either fuel would depend on the yield of the biomass feedstock used in manufacturing that fuel.

Biomass gasification with the addition of hydrogen prior to catalytic conversion into methanol has the potential to generate much greater quantities of transportation fuel from a given supply of biomass feedstock, approximately 330 gallons of methanol per ton of biomass fiber (Takahashi, 1989), than the other processes summarized above; however, that alternative requires the addition of large amounts of hydrogen, which, practically speaking, probably would need access to large amounts of inexpensive electricity (itself, an important energy product). Since hydrogen-augmented-biomethanol conversion was determined to be more costly than other biomethanol alternatives in spite of its dramatic yield advantage (Takahashi, 1989), the hydrogen-augmented-biomethanol alternative is not examined in this analysis (that conversion alternative is mentioned mainly to illustrate the significant quantity of transportation fuel that can be produced from biomass).

The conversion efficiencies for the two biomass-to-electricity options listed in Table 7-11 are averages of published and unpublished values (e.g., Larson and Williams, 1990; Electric Power Research Institute and SFA Pacific, 1993; Craig and Mann, 1993; Bain, 1994). The steam-turbine cycle, based on spreader-stoker boilers or fluidized-bed boilers, represents conventional biomass electricity generation technology. The gas-turbine combined cycle incorporates advanced, but commercially available aero-derivative or industrial gas turbine technology with existing steam generation technology. Although the power generation portions of gas-turbine based systems are commercial, their integration with biomass gasification and clean-up of the biomass-derived gas still are in the developmental stage. Scale-up and demonstration of those technologies presently are underway in Hawaii (Overend et. al., 1992) and elsewhere; technological risk is considered by most in the field to be moderate. Given the relatively low developmental risk of such technology and the relatively short lead time anticipated for commercializing the technology, only the gas-turbine-based option is considered in the following discussion on electricity cost.

7.3 ESTIMATED PRODUCTION COST OF TRANSPORTATION FUELS AND ELECTRICITY FROM HAWAII BIOMASS

7.3.1 COST OF BIOMASS FEEDSTOCKS

Projected feedstock costs are very site specific, depending on such factors as scale of operation, the amount of irrigation water needed and its cost, and the type of harvesting and transporting system employed. Therefore, it is not surprising that whereas there appears to be some consensus on likely commercial yields of biomass-for-energy crops, there seems to be much less agreement on the cost of growing, harvesting, and transporting energy crops to the biomass conversion plant. The projected cost of producing and delivering biomass feedstocks to a central receiving point varies widely (e.g., Hubbard and Kinoshita, 1993; Osgood and Dudley, 1993; Phillips et. al., 1993; Troy, 1982; Whitesell et. al., 1992) from approximately $30 per ton (dry basis) to nearly $100 per ton.

For the comparisons in this chapter[2], it was agreed to use three different feedstock costs - low, intermediate, and high - as the bases for estimating transportation fuels and electricity production costs. The three feedstock costs (dry basis, free-on-board (FOB) conversion plant gate) assumed for this investigation are: $40 per ton (low); $50 per ton (intermediate); and $60 per ton (high). The feedstock is assumed to be delivered to the conversion facility in partially processed form (e.g., prepared cane, chopped banagrass, or woodchips).

7.3.2 LIQUID FUEL COST

7.3.2.1 Ethanol

In this investigation, the cost of producing ethanol from sugarcane is extrapolated from Shleser (1993a and 1993b). In the study leading to these reports, developers of competing ethanol-from-biomass technologies[3] provided cost data for the following categories: biomass feedstock; chemicals; utilities; general and administrative; labor and benefits; property taxes and insurance; and capital. To evaluate the competing technologies and their economics on a comparative basis, scaling factors were applied to the data provided by the developers to project ethanol costs from conversion facilities having capacities of 5 mgpy and 25 mgpy. The ethanol production costs (excluding feedstock cost) for the competing technologies are plotted in Figure 7-5. Also plotted in Figure 7-5 is an averaged ethanol conversion cost versus capacity curve, calculated from the 5 mgpy and 25 mgpy projections for the seven competing technologies, using the scaling factors assumed by Shleser. The cost-versus-scale curve in Figure 7-5 forms the basis of the ethanol costs used in this investigation.

7.3.2.2 Methanol

Price estimates for methanol from biomass are summarized in Table 7-12. Base prices for methanol are derived from calculated unit prices of methanol at the plant gate, adjusted to the following base conditions: methanol yield equals 150 gallons per ton of feedstock (Takahashi, 1989); 1991 dollars. The base prices presented in Table 7-12 include estimates by HNEI (Takahashi, 1986; Takahashi, 1989) for three production scales and estimates by the National Renewable Energy Laboratory (NREL) (Bain, 1993) for two scales. The price figures presented at the bottom of Table 7-12 are adjusted to exclude feedstock costs. These final price figures form the basis for the estimated price of methanol produced from biomass feedstocks delivered to the conversion facility at the range of feedstock costs considered in the present analysis.

It must be recognized that the original price figures given in Table 7-12 were derived in terms of the particular set of conditions selected by the investigators of the individual studies. Some of those conditions have been normalized by use of the adjustments indicated in that table. Other assumptions used could prove to be inaccurate when an actual plant is constructed

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[2] In the alcohol production cost scenarios of Chapter 8, feedstock costs are based on a range of estimates of commercially-achievable yields and costs.

[3] Including simultaneous saccharification and fermentation; acetone extraction and fermentation; steam explosion; ammonia explosion with recycling; acid hydrolysis and genetically engineered fermentation; concentrated acid hydrolysis with recycling; and concentrated acid hydrolysis.

and operated, but no adjustments have been made for such variations. For example, the 1989 HNEI study assumes an integrated methanol production system involving a geothermal power plant providing electricity at 4.22 cents per kWh and an independent oxygen plant adjacent to the methanol plant, providing oxygen at $20 per ton. It is likely that any variations in actualizing such elements would lead to increased methanol prices. On the other hand, variations in other assumptions could lead to decreased prices (e.g., assumptions that there would be no tax credits for the project and that no by-product credit would be obtained for the carbon dioxide produced). The adjusted unit price of methanol, less feedstock cost, FOB conversion plant gate (bottom row of numbers in Table 7-12), is plotted in Figure 7-6. The best-fit curve forms the basis of the methanol prices used in this investigation.

7.3.2.3 Comparison Of Fuel Costs

The costs of producing ethanol and methanol from biomass are presented in Table 7-13 for selected cases to illustrate the influences of scale of conversion facility and cost of feedstock on the overall fuel cost. The cost of ethanol is based on the cost curve in Figure 7-5, with the cost of the feedstock included. The cost of methanol is based on the best-fit price curve in Figure 7-6. Three feedstock costs and three different production scales, representing small, medium, and large plants (three sizes for ethanol production and three sizes for methanol production) are assumed in the analysis leading to Table 7-13.

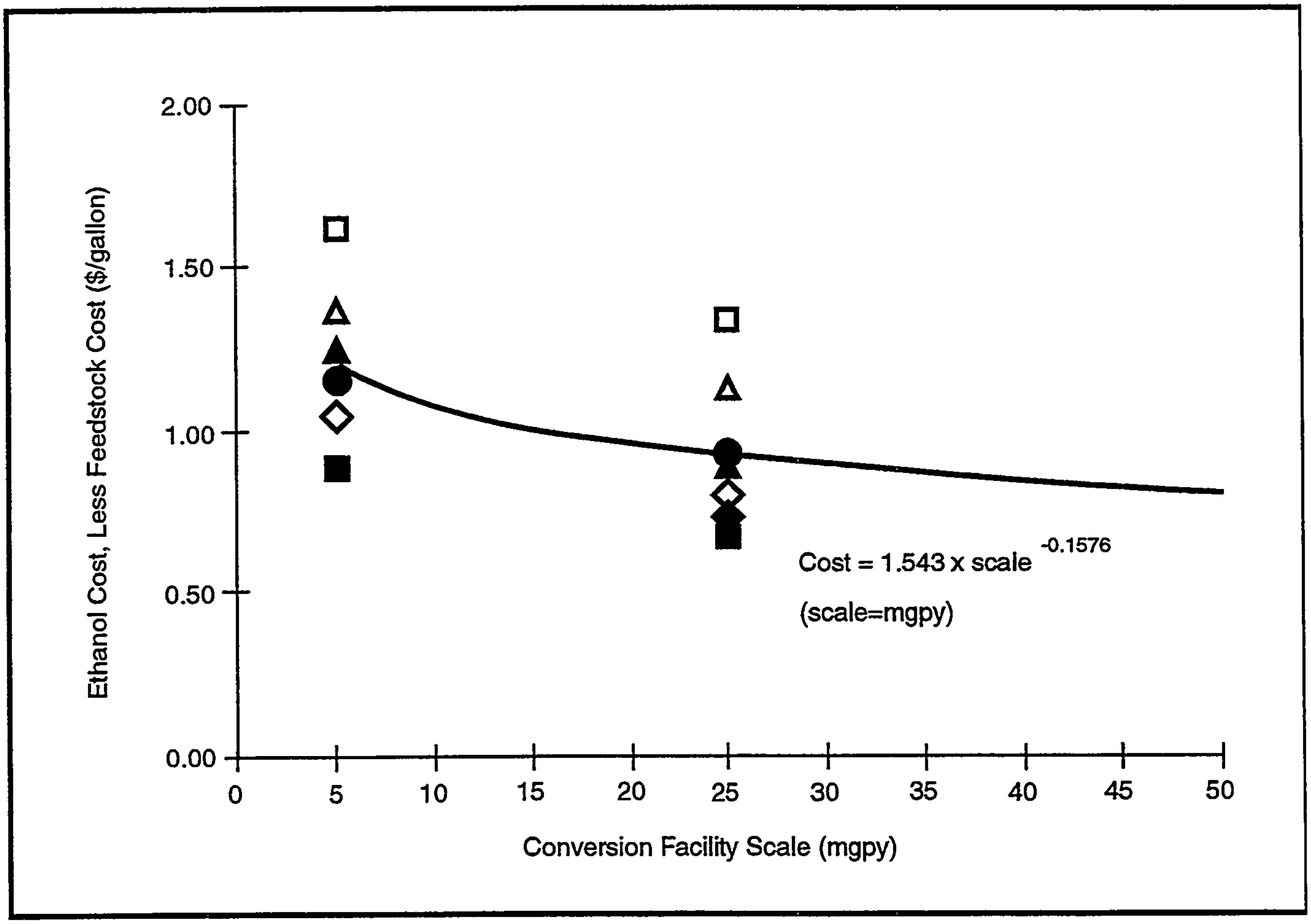
Within the range of parameters considered in Table 7-13, the plant-gate cost for ethanol varies from $1.20 to $1.74 per gallon ($1.79 to $2.61 per gasoline-equivalent gallon) and that for methanol varies from $0.67 to $1.24 per gallon ($1.35 to $2.48 per gasoline-equivalent gallon), increasing as the scale of the plant decreases and the cost of the feedstock increases. Although the gasoline-equivalent cost for methanol appears to be somewhat lower than that for ethanol, the production size required to approach economic scales in methanol plants is much larger than for ethanol plants (the costs of both fuels are comparable when evaluated at equivalent production scales). Also, the feedstock supply infrastructure for the ethanol-from-sugarcane option already is in place; whereas the feedstock supply infrastructure for methanol production must be established whether the feedstock consists of banagrass or trees.

It should also be noted that other studies (e.g., Wyman et. al., 1993) have projected that with scale-up of existing technology, ethanol from biomass should have a plant-gate cost of roughly $1.00 per gallon, lower than even the lowest cost shown in the preceding table ($1.20 per gallon for ethanol produced in a large plant from biomass costing $40 per ton); those same studies project even lower ethanol production costs with anticipated improvements in technology.

Previous studies have suggested numerous byproducts that might potentially accrue from alcohol production which would offset production costs. While byproduct credits are not considered in this investigation, their potential to significantly reduce the net cost of producing alcohol fuels from biomass is acknowledged; indeed, a more detailed study of their impact on the economics of alcohol fuels production seems warranted.

Figure 7-5

Production Cost of Ethanol-from-Sugarcane, Less Feedstock Cost



Source: Shleser, 1993a.

Note: Data symbols differentiate seven technologies.

Table 7-12

Estimated Price for Methanol from Biomass

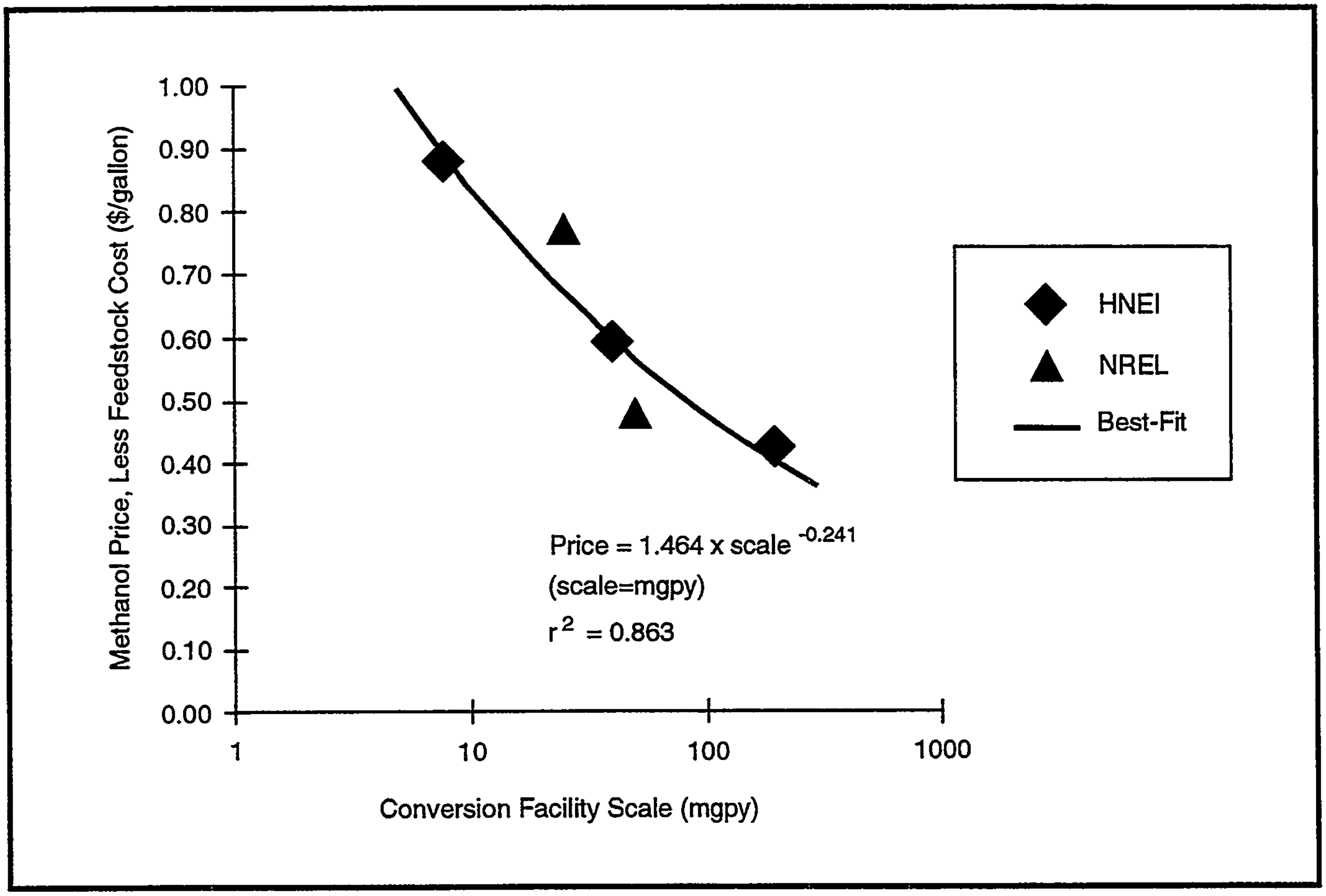
Case[1]	HN1	NR1	HN2	NR2	HN3
Reference date of price values	1988	1991	1988	1991	1988
Scale (mgpy)	7.8	25	40	50	200
Feedstock cost ($/ton)	30	23.59	30	24.49	30
Methanol yield (gal/ton)	150	185.7	150	185.7	150
Unit price[2] ($/gal)	1.00	0.75	0.74	0.52	0.59
Adjusted (Base) price, less feedstock cost[3] ($/gal)	0.89	0.77	0.60	0.48	0.43

Notes:

1) "HN" denotes 1989 HNEI study (Takahashi, 1989); "NR" denotes 1993 NREL study (Bain, 1993).
2) Original numbers from 1993 NREL study and 1989 HNEI study, with smaller scale plants of the HNEI work (7.8 and 40 mgpy) recalculated from 1986 prices (Takahashi, 1986) using updated capital and operating costs from 1989 study, plus plant cost index adjustment.
3) Adjusted to Base conditions: Methanol yield = 150 gal/ton feedstock (assumes that methanol cost is inversely proportional to yield) and 1991 dollars, adjusted according to Chemical Engineering plant cost index for overall cost (Chemical Engineering, 1990); feedstock cost is deleted to make final price feedstock-price-neutral.

Figure 7-6

Adjusted Methanol Price, Less Feedstock Cost



Source: See Table 7-12.

Table 7-13

Estimated Unit Cost of Alcohol Fuels from Biomass, FOB Conversion-Facility Gate

	Plant Scale					
	Small		Medium		Large	
Ethanol from Sugarcane						
Production						
Fuel production (mgpy)	5		2		50	
Biomass feedstock(tpd)[1]	138		68		1380	
Plant-gate cost (equivalent)[2]	$/gallon	$/gallon gasoline	$/gallon	$/gallon gasoline	$/gallon	$/gallon gasoline
@ $40/ton feedstock	1.56	2.34	1.29	1.94	1.20	1.79
@ $50/ton feedstock	1.65	2.48	1.38	2.08	1.29	1.93
@ $60/ton feedstock	1.74	2.61	1.47	2.21	1.38	2.07
Methanol from Fiber						
Production						
Fuel production (mgpy)	10	10	5		200	
Biomass feedstock(tpd)[1]	202	202	101		4040	
Plant-gate cost (equivalent)[2]	$/gallon	$/gallon gasoline	$/gallon	$/gallon gasoline	$/gallon	$/gallon gasoline
@ $40/ton feedstock	1.11	2.21	0.84	1.67	0.67	1.35
@ $50/ton feedstock	1.17	2.35	0.90	1.81	0.74	1.48
@ $60/ton feedstock	1.24	2.48	0.97	1.94	0.81	1.62

Notes:

1) Assumes ethanol-from-sugarcane yield = 110 gal/ton (dry basis); methanol-from-fiber yield = 150 gal/ton (dry basis); assumes 330 operating days per year.
2) Fuel equivalency based on equivalent lower heating values. Lower heating values used (Davis and Strang, 1993): ethanol = 76,000 Btu/gallon; methanol = 56,800 Btu/gallon; gasoline = 114,000 Btu/gallon (average of range of values used for gasoline); thus, 1 gallon gasoline = 1.5 gallons ethanol = 2.0 gallons methanol.

Feedstock is a major component in the overall cost of producing transportation fuels from biomass. Based on the conversion efficiencies assumed in this analysis, 110 gallons of ethanol per ton of sugarcane dry matter and 150 gallons of methanol per ton of fiber, each $10 per ton (dry basis) increment in feedstock cost translates to a 13 cents per gallon (gasoline-equivalent basis) differential in ethanol or methanol fuel cost. The scale of the conversion facility (determined largely by the size of the biomass plantation that serves the facility and the crop yield) and feedstock cost both influence the unit cost of alcohol fuel significantly. It is likely that at intermediate scales of production, savings accrued in increasing plantation and facility size would be offset by higher costs in transporting biomass longer distances to the conversion facility.

7.3.3 ELECTRICITY COST

Only gas-turbine combined cycle systems, presently under development, are considered in estimating the cost of biomass-derived electricity. The cost is based on estimates from four independent technoeconomic evaluations of biomass gasifier/gas-turbine combined-cycle electricity generation systems. The four separate evaluations are described in a detailed comparative study by Craig and Mann (1993). The same four systems were reevaluated by Bain (1994); the results of the reevaluation, less feedstock cost, are summarized in Table 7-14.

Explanations for the substantial differences in the four estimates of electricity generation cost in Table 7-14 are offered by Craig and Mann (1993). The average values for unit cost and scale ($0.054 per kWh at 56 MW) in Table 7-14 are used as the basis of the present investigation. A comparison of the projected costs for eleven biomass power systems (Craig and Mann, 1993) suggests that unit cost ($ per kWh) scales roughly with capacity (MW) according to a 0.7 power. That power factor is applied to the aforementioned base cost and scale ($0.054 per kWh at 56 MW) to project electricity costs, less feedstock cost, for electricity generation facilities of different sizes.

In parallel with Table 7-13, for the liquid fuels, the cost of producing electricity from biomass is presented in Table 7-15 for selected cases to illustrate the influences of scale of generation facility and cost of feedstock on the overall cost of producing electricity.

Table 7-14

Technical and Cost Data for Four Biomass Integrated Gasification Combined Cycle Power Systems[1]

	EPRI	**Tecogen**	**Ebasco**	**NREL**	**Average**
Facility Size (MW)[1]	50	50	64	60	56
Capital Cost ($/kW)[1]	3,005	1,850	1,706	1,680	2,060
Efficiency (%)	28	29	29	37	31
Electricity Cost (cents/kWh)[1]					
Capital	4.2	2.6	2.3	2.3	2.9
O&M	4.1	2.1	1.7	2.4	2.6
Total (less feedstock)	8.3	4.7	4.0	4.7	5.4

Source: Bain, 1994

Note:

1) Net power generation; all figures are rounded.

Table 7-15

Estimated Unit Cost of Electricity from Biomass

	Plant Scale		
	Small	Medium	Large
Production			
Electricity generation (MW)	10	50	100
Biomass feedstock (tpd)[1]	167	833	1,670
Plant-gate cost (cents/kWh)			
@ $40/ton feedstock	11.8	8.4	7.3
@ $50/ton feedstock	12.5	9.1	8.0
@ $60/ton feedstock	13.2	9.8	8.7

Note:
1) Assumes electricity-from-fiber yield = 1440 kWh/ton (dry basis).

7.4 TOTAL AMOUNT AND COST OF TRANSPORTATION FUELS AND ELECTRICITY PRODUCIBLE FROM BIOMASS

7.4.1 DISTRIBUTION OF LAND FOR BIOENERGY CONVERSION

The limited scope of this investigation does not permit precisely matching discrete tracts of land with conversion systems so that crop production/delivery are optimized with fuel or electricity generation. Instead, in this investigation, the lands and the crops grown on those lands are assumed to be distributed evenly between the conversion plants on each island. The assumed distributions of lands and crops to biomass conversion facilities are summarized in Table 7-16.

7.4.2 TRANSPORTATION FUELS PRODUCTION

The amounts of alcohol fuels and the unit costs of fuels producible from sugarcane (ethanol), and banagrass or tree crops (methanol), calculated on the basis of the land allocations presented in Table 7-16, the feedstock amounts in Table 7-10, and the intermediate feedstock cost of $50 per ton, are summarized in Table 7-17.

7.4.3 ELECTRICITY PRODUCTION

The average size of electrical generation facility, and the amount and unit cost of electricity producible from banagrass or tree crops, calculated on the basis of the land allocations presented in Table 7-16, the feedstock amounts in Table 7-10, and the intermediate feedstock cost of $50 per ton, are summarized in Table 7-18.

7.4.4 SUMMARY OF STATEWIDE PRODUCTION OF TRANSPORTATION FUELS AND ELECTRICITY FROM BIOMASS

Because banagrass is higher yielding than trees, more banagrass can be delivered from a tract of land to a given conversion facility than woodchips. The higher tonnage in turn allows the conversion facility to achieve greater economies of scale with banagrass than with woodchips, and consequently the cost of methanol or electricity would be lower with banagrass (as seen in Table 7-17 and 7-18). However, if woodchips can be delivered to the conversion facility at a lower price than banagrass, then the lower price for the woodchip feedstock might offset its higher conversion cost and make the overall cost of biofuel from woodchips comparable to or even lower than the overall cost of biofuel from banagrass.

Based on the land-use scenarios summarized in Table 7-8, the crop yield estimates presented in Table 7-9, and the conversion efficiencies summarized in Table 7-11, it appears that the amounts and costs of transportation fuels or electricity producible from biomass statewide are as presented in Table 7-19. The reader is reminded that these are gross estimates based on simplifying assumptions, developed solely for the purposes of providing order-of-magnitude estimates for this project; actual crops, yields, and costs could vary significantly depending on site, weather conditions, financing, sales of byproducts, market conditions, status of technology, and many other factors.

Table 7-16

Hypothetical Distribution of Land for Bioenergy (Biomass to Ethanol, Methanol, or Electricity) Conversion

Scenario[1]	Number of Facilities: Average Crop Acreage Per Facility (1,000 acres)				
	Hawaii	**Kauai**	**Maui[2]**	**Oahu**	**Total Facilities: Average Acreage**
1	3:19	4:9	3:14	2:12	12:13
2E	3:17	1:11	1:17	1:22	6:17
2M	2:25	1:11	1:17	1:22	5:20
3E	4:18	5:9	4:18	2:19	15:15
3M	2:37	2:22	2:35	2:19	8:28
4E	6:21	5:11	4:22	3:20	18:18
4M	3:41	2:27	2:44	2:30	9:36

Notes:

1) See Table 7-8 for description of land-use scenarios. "E" denotes sugarcane to ethanol conversion or biomass fiber (banagrass or tree crop) to electricity conversion; "M" denotes biomass fiber (banagrass or tree crop) to methanol conversion.
2) Data for Maui island includes entire Maui county which comprises the islands of Maui, Molokai and Lanai. Therefore, Maui island figures are slightly overestimated.

Table 7-17

Amounts and Unit Costs of Alcohol Fuels Producible from Biomass[1]

Scenario	Hawaii	Kauai	Maui	Oahu	Average
	Average ethanol production per facility from sugarcane (mgpy)				
1	10	7	13	10	10
2	29	19	30	38	29
3	38	19	37	40	32
4	40	22	44	39	36
	Average unit cost of ethanol produced from sugarcane ($/gal)				
1					
2	1.36	1.43	1.36	1.32	1.37
3	1.32	1.43	1.33	1.32	1.36
4	1.32	1.40	1.30	1.32	1.34
	Average methanol production per facility from banagrass: trees (mgpy)				
1	N/A	N/A	N/A	N/A	N/A
2	67:37	28:16	46:26	59:33	54:30
3	121:66	73:40	116:64	63:34	93:51
4	125:69	87:48	140:76	92:51	113:62
	Average unit cost of methanol produced from banagrass: trees ($/gal)				
1	N/A	N/A	N/A	N/A	N/A
2	0.86:0.95	0.99:1.09	0.91:1.00	0.88:0.97	0.90:0.99
3	0.79:0.87	0.85:0.94	0.80:0.87	0.87:0.96	0.83:0.91
4	0.79:0.86	0.83:0.91	0.78:0.85	0.83:0.90	0.80:0.88

Note:

1) On basis of lower heating values, fuel equivalency is: 1 gallon gasoline = 1.5 gallons ethanol = 2.0 gallons methanol.

Table 7-18

Generation Scale, Amount and Unit Cost of Electricity Producible from Biomass

Scenario	Hawaii	Kauai	Maui	Oahu	Average
	Average output per generation facility using banagrass: trees (MW)				
1	N/A	N/A	N/A	N/A	N/A
2	54:30	35:19	56:31	71:40	54:30
3	73:40	35:19	71:39	76:42	60:33
4	76:42	42:23	85:46	75:41	68:37
	Average annual production per facility using banagrass: trees (million kWh)				
1	N/A	N/A	N/A	N/A	N/A
2	430:239	273:152	443:246	565:314	429:238
3	581:317	281:153	559:305	604:329	478:261
4	602:331	336:184	670:367	591:324	541:297
	Average unit cost of electricity produced from banagrass: trees (cents/kWh)				
1	N/A	N/A	N/A	N/A	N/A
2	8.9:10.0	9.7:10.9	8.9:9.9	8.5:9.5	9.0:10.0
3	8.5:9.4	9.7:10.9	8.5:9.5	8.4:9.4	8.9:9.9
4	8.4:9.4	9.3:10.5	8.2:9.2	8.4:9.4	8.6:9.7

Table 7-19

Summary of Statewide Production of Transportation Fuels (Fuel Amounts and Unit Costs Are Shown on Gasoline-Equivalent Bases) and Electricity from Biomass[1]

	Acreage	Ethanol[1,2]		Methanol[1,2]		Electricity[2]	
Scenario	(1000 ac)	(mgpy)	($/gal)	(mgpy)	($/gal)	(MW)	(cents/kWh)
1	156	79	*	N/A	N/A	N/A	N/A
2	99	116	2.05	134:74	1.80:1.98	325:180	9.0:10.0
3	226	315	2.04	374:204	1.66:1.82	906:494	8.9:9.9
4	326	432	2.01	507:278	1.61:1.76	1230:674	8.6:9.7

Notes:

1) Fuel equivalency assumed: 1 gallon gasoline = 1.5 gallons ethanol = 2.0 gallons methanol.
2) Amounts and costs refer to ethanol from sugarcane, and methanol and electricity from banagrass: trees.
*) No data available from Hawaii Natural Energy Institute.

CHAPTER 8

COST ANALYSES OF SCENARIOS OF ALTERNATIVE FUEL USE IN HAWAII'S GROUND TRANSPORTATION SECTOR

8.1 INTRODUCTION

This Chapter estimates the costs associated with alternative fuel use in Hawaii's ground transportation sector. The estimates are based on the vehicle technologies discussed in Chapter 4, the infrastructure requirements discussed in Chapter 6, and land use and fuel production discussed in Chapter 7. Cost estimates are constant dollars.

Cost projections are retail, "at-the-pump" amounts into which all infrastructure, shipping costs, and taxes have been taken into account. Results are shown to the nearest cent because it is handy to use this format when comparing alternative fuel costs to gasoline prices at the pump. The range between the "low" and "high" cost estimates are intended to give an indication of relative uncertainty of the estimates.

Cost estimates for each of the alternative fuels have a different emphasis. For the alcohol fuels, since manufacturers are currently pricing alcohol and comparable gasoline cars at the same level, the most important element becomes the cost of the fuel. Biodiesels are similar to alcohols in that the main cost element is fuel cost. For electric vehicles, both vehicle cost and fuel (electricity) costs are considered; however, emphasis is on the vehicle technology and cost. For propane, both vehicle and fuel costs are considered.

The results of the cost evaluations are useful in considering the following questions:

- Are any of the alternative fuel options which passed the screening analysis currently cost-competitive with gasoline or diesel? If not, to what extent are the alternatives more expensive?
- What are the key cost factors and how can they be reduced?
- If a public subsidy is necessary to support an alternative fuels program, what level of support would be required? (This is discussed further in Chapters 9 and 10, using the results of the cost analyses.)
- Is it possible to structure an alternative fuels program so that the benefits justify the costs? If so, how? (Results of the cost evaluations form the basis for discussion in Chapters 9, 10, and 11.)

Although these questions are addressed in this study *for the current situation,* results will change as costs and technologies change. The estimation tools developed in this project are intended to readily allow this type of re-evaluation.

8.2 ALCOHOLS: METHANOL AND ETHANOL

8.2.1 SCOPE AND ORGANIZATION

The analysis focuses on a limited number of scenarios, outlined below, which are useful in developing policy. Because cars and light trucks fueling at retail stations account for a large percentage of gasoline consumption, the fuel cost projections are for fuels sold through retail stations.[1]

Cost analysis results are in dollars per gasoline equivalent gallon (GEG) at the pump.[2] In this analysis, we make the conservative assumption that the efficiency of alcohol flexible-fuel vehicles (FFVs) is equal to gasoline vehicle efficiency.[3] All production costs for methanol produced from biomass and ethanol produced from sugar cane are taken from Chapter 7.

8.2.2 METHANOL SCENARIOS

Scenario M1a: Methanol Shipped from Canada: Container Shipment

In this scenario, Canadian[4] methanol would be imported in 6100 gallon tanks (Henry, 1993) and trucked directly to the methanol refueling stations. Gasoline would be added to the M85 tank separately. This is the most likely supply scenario for methanol when volumes are fairly low and before local production could commence.[5] A range of importation volumes is considered, from a single container (about 6000 gallons M100) to enough M100 to reduce retail station per gallon costs to an approximately constant and small level (about 170,000 gallons M100).

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[1] This could include privately owned and operated vehicles as well as vehicles in commercial fleets which fuel at retail stations. Costs could be different for government fleets or centrally-fueled commercial fleets. Costs will also be different for heavy-duty vehicles in a variety of applications.

[2] A "gasoline equivalent gallon" (GEG) is that volume of alcohol which contains as much energy as a gallon of gasoline. For M85 (85 percent methanol, 15 percent gasoline), a gasoline equivalent gallon is about 1.75 gallons. For E85 (85 percent ethanol, 15 percent gasoline), a gasoline equivalent gallon is about 1.4 gallons. Given equal efficiency of converting the fuel to power at the wheels, a vehicle would go as far on a gasoline equivalent gallon of alcohol as it would on a gallon of gasoline.

[3] Data shows that current FFVs operating on M85 are slightly more efficient than comparable gasoline vehicles. Gasoline equivalent mileage of current FFVs on M85 is about 3 to 11 percent higher than that of vehicles using industry average gasoline, and 6 to 16 percent higher than that of vehicles operating on California Phase 2 reformulated gasoline (Browning, 1993).

[4] The (low and high) price assumed is the range of prices adopted for methanol sold through the California Methanol Reserve. The methanol sold through the reserve comes from Canada and therefore includes all applicable duties and tariffs. California uses Canadian methanol because the American methanol industry does not have the excess capacity to supply the Reserve.

[5] HNEI estimates that to achieve reasonable economy of scale, a fiber-to-methanol plant would need to manufacture at least 50 million gallons of methanol per year. As part of this study, HNEI sized the first methanol plant on Oahu at 59 million gallons per year (mgpy) of methanol (see Chapter 7). To provide a range of estimates, however, this study includes costs for fiber-to-methanol plants as small as 10 mgpy. Fiber could be provided by any of a number of feedstocks, from bagasse to dedicated energy crops such as grasses and trees (fiber-to-methanol technology is still under development). HNEI estimates it would take up to 10 years to bring such a plant on-line.

Scenario M1b: Methanol Shipped from Canada: Parcel Tanker Shipment

In this scenario, methanol would be imported in a parcel tanker. This scenario is a variation on the scenario above and would apply at higher import volumes.[6] In the parcel tanker scenario, a terminal would be built at Barbers Point to receive the methanol.[7] Tank trucks are assumed to load gasoline at the Honolulu Harbor terminal and methanol at the Barbers Point terminal and transport M85 (blended in the tank truck) to the stations. Volumes from 714,000 gallons to over 60 million gallons per year (mgpy) of M100 are considered.

Scenario M2a: Methanol Produced on Oahu from Fiber

In this scenario, methanol would be produced on Oahu from fiber.[8] The methanol would be trucked directly from the plant to methanol refueling stations. The plant gate price is assumed to include the cost of enough live storage at the plant to remove the need for an intermediate storage facility, such as a tank farm. The tank trucks are assumed to first take on 15 percent gasoline by volume at the Honolulu Harbor terminal. This assumption is made because it would be safer to haul methanol/gasoline blends than pure methanol, as was described in Chapter 6. Three production volumes are investigated: small volume (10 mgpy), volume large enough to achieve reasonable economy of scale (59 mgpy), and large volume (two 92 mgpy plants). These larger volumes correspond to the plant sizes estimated for Oahu in Chapter 7.

Scenario M2b: Methanol Produced from Coal Gasification on Oahu

In this scenario, methanol would be produced on Oahu from coal. In all other respects, except for tax treatment, this scenario is identical to scenario M2a.

Scenario M3: Methanol Produced from Fiber on a Neighbor Island and Transported by Barge to Oahu

In this scenario, methanol would be produced on a neighbor island, trucked to a terminal facility (Hilo, on the Island of Hawaii, was used for the purposes of cost estimates), and transported by tanker barge to Oahu. The methanol would be received at a terminal at Barbers Point and trucked from the terminal to methanol refueling stations, as in the parcel tanker scenario. Three production volumes are investigated: small volume (10 mgpy), volume large enough to achieve reasonable economy of scale (67 mgpy), and large volume (375 mgpy, produced at three 125 mgpy plants). These larger volumes correspond to the plant sizes estimated for the Big Island in Chapter 7.

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[6] Parcel tanker shipment was originally assumed to become more economical than container shipment at volumes greater than about 840,000 gallons (20,000 barrels or about 140 containers) based on industry estimates (Henry, 1993), and a 20,000 barrel terminal, assumed to be built at Barbers Point to receive the methanol from the parcel tanker, was costed as part of this study. However, further assessment showed that at 20,000 barrels annual throughput, the expense of the terminal exceeds the shipping cost savings associated with bulk shipments. Parcel tanker shipments appear to become more economical for annual volumes of about 1.5 mgpy.

[7] The State of Hawaii's Department of Transportation's Harbor Division would not allow the Honolulu Harbor to receive methanol because the Harbor Division is trying to rid the Honolulu Harbor of hazardous land uses.

[8] This scenario would apply to any island producing alcohol fuel and consuming all of that which is produced. In this study Oahu is used for this scenario since transportation energy consumption on Oahu is much greater than on the other islands.

8.2.3 ETHANOL SCENARIOS

Scenario E1a: Ethanol Shipped from Canada: Container Shipment and Sold as E85

In this scenario, ethanol would be imported via container ships and then hauled by truck (one container per truck) directly to the ethanol refueling stations. Gasoline (15 percent by volume) would be added to the E85 tank either before or just after the ethanol delivery, at the time of a regularly scheduled gasoline drop. This would be a possible supply scenario for ethanol in the early years when volumes are fairly low and before an in-state biomass conversion facility could be built.[9] A range of annual import/consumption volumes is considered, from a single container (about 6000 gallons E100) to enough E100 to reduce retail station per gallon costs to an approximately constant and small level (about 170,000 gallons E100).

Scenario E1b: Ethanol Shipped from Canada: Container Shipment and Sold as E10

In this scenario, ethanol would be imported via container and then hauled by truck (one container per truck) directly to the terminal. A range of annual import/consumption volumes is considered, from a single container (about 6000 gallons E100) to about 170,000 gallons E100. All of the E10 scenarios include an incremental gasoline cost of 2 cents per gallon for refiners to reduce gasoline volatility. Since adding small amounts of ethanol to gasoline results in a higher volatility, controlling the initial gasoline volatility is necessary to insure compliance with American Society for Testing and Materials (ASTM) standards (State DBEDT, 1991).

Scenarios E2a and E4a: Ethanol Produced on Oahu and Sold as E85

In these scenarios, ethanol would be produced on Oahu from waste paper, green waste, and other organic constituents of municipal solid waste (MSW) (scenario E2a) or sugarcane (scenario E4a) and transported by truck from the plant to ethanol refueling stations. The trucks are assumed to take on 15 percent gasoline by volume at the Honolulu Harbor terminal before driving to the ethanol plant to load ethanol. This is identical to scenario M2 except that the fuel would now be ethanol instead of methanol. Costs would be the same for the two scenarios except for tax treatment and plant gate price. Two production volumes, 7 mgpy and 30 mgpy, are shown for each scenario. For ethanol from MSW, these sizes correspond to quantities of waste material (7 mgpy from waste paper; 30 mgpy from total organic fraction of the waste stream) available on a single island (Oahu).

Scenarios E2b and E4b: Ethanol Produced on Oahu and Sold in Gasohol (E10)

In this scenario, ethanol would be produced on Oahu, as described in Scenarios E2a and E4a above, and transported by truck to terminal facilities at the harbor. Ethanol would be blended at 10 percent by volume at the rack and the E10 would be transported to refueling stations by truck.

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[9] Ethanol production is less sensitive to economies of scale than plants that manufacture methanol from biomass. HNEI estimates that facilities to produce ethanol could be built as small as about 5 mgpy without poor economy of scale. Production of ethanol from sugars is a proven technology which could be implemented immediately. Independent of the scenario-dependent schedules in which we predict a demand of this magnitude to develop (see Chapter 4), HNEI estimates it would take up to 10 years to bring a (cellulose plus hemicellulose) fiber-to-ethanol plant on-line. Fiber could be provided by any of a number of feedstocks, from municipal solid waste (MSW) to energy crops such as grasses and trees.

Scenario E3a and E5: Ethanol Produced on a Neighbor Island, Transported by Barge to Oahu and Sold as E85

In these scenarios, ethanol would be produced on a neighbor island from molasses (E3a) or sugarcane (E5), trucked to a terminal facility (Hilo, on the Island of Hawaii, was used for the purposes of cost estimates), and transported by tanker barge to Oahu. The ethanol would be received at a terminal at Barbers Point and trucked from the terminal to the ethanol refueling station. This would be identical to scenario M3 except that the fuel would be now ethanol instead of methanol. Costs are the same for the two scenarios except for tax treatment and plant gate price. Two production volumes, 1 mgpy and 3 mgpy, corresponding to maximum availability of molasses on a single island, are used for the molasses scenario. For ethanol from sugarcane, production volumes of 60 and 100 mgpy (two 30 mgpy plants and two 50 mgpy plants) are used.

Scenario E3b: Ethanol Produced on a Neighbor Island, Transported by Barge to Oahu and Sold in Gasohol (E10)

In this scenario, ethanol would be produced on a neighbor island from molasses (E3b), trucked to a terminal facility (Hilo, on the Island of Hawaii, was used for the purposes of cost estimates), and transported by tanker barge to Oahu. The ethanol would be received at a terminal at Barbers Point and transported by truck to terminal facilities. Ethanol would be blended at 10 percent by volume at the rack and the E10 would be transported to refueling stations by truck.

8.2.4 RESULTS OF THE ALCOHOL SCENARIOS

8.2.4.1 PROJECTED ALCOHOL FUEL COST AT THE PUMP FOR VARIOUS SCENARIOS

Results for the methanol scenarios are shown in Table 8-1. Projected methanol (M85) costs at the pump, in gasoline equivalent gallons (GEG), range from a high of $6.06 to a low of $1.79, depending on the supply scenario and the volume of annual demand. The highest prices are seen in the containerized import scenario (M1) at very small volumes, and the lowest in the scenario of production from fiber and use on the same island (no inter-island barge transport) (M2a) with the highest volume.

The column showing prices "With GEG-adjusted Taxes" shows projected costs if state and county fuel taxes were adjusted on the basis of energy content. This would be a reasonable, fuel-neutral adjustment and would not involve any subsidies, tax incentives, or redirection of funds (and the alternative fuels still pay their "fair share" of highway taxes). This is discussed further in Chapter 9. Projected costs at the pump with this adjustment range from a high of $5.79 to a low of $1.52, depending on scenario and volume.

Results for the ethanol scenarios are shown in Table 8-2. Projected low-level ethanol blend (E10) costs at the pump range from a high of $1.77, with the highest costs seen in the containerized import scenario, to a low of $1.52 in the scenario of production from MSW and use on Oahu (E1b).

Table 8-1
Results of Methanol Cost Analyses

Methanol Scenarios	Methanol Annual Volumes (gallons 100% alcohol)	**Sold as M85**			
		With Existing Taxes		With GEG-adjusted Taxes (2)	
		Low Pump Price ($/GEG) (1)	High Pump Price ($/GEG)	Low Pump Price ($/GEG)	High Pump Price ($/GEG)
M1a. Methanol Imported - Containers	6,000	$2.86	$6.06	$2.59	$5.79
	170,000	$2.87	$3.59	$2.60	$3.32
M1b. Methanol Imported - Parcel Tanker	714,000	$3.61	$4.50	$3.34	$4.23
	1,275,000	$2.93	$3.52	$2.66	$3.25
	>60,000,000	$2.09	$2.35	$1.82	$2.08
M2a. Methanol Made from Banagrass on Oahu	10,000,000	$2.23	$3.57	$1.96	$3.30
	59,000,000	$1.86	$3.09	$1.59	$2.82
	184,000,000	$1.79	$2.92	$1.52	$2.65
M2b. Methanol Made from Coal with electricity co-production	1,247,000	$2.89	$2.90	$2.62	$2.63
	1,247,000	$2.27	$2.28	$2.00	$2.01
M3. Methanol Made from Banagrass on a Neighbor Island and Shipped to Oahu	10,000,000	$2.72	$4.16	$2.45	$3.89
	67,000,000	$2.13	$3.35	$1.86	$3.08
	375,000,000	$2.02	$3.13	$1.75	$2.86

Notes:

1. $/GEG refers to $ per gasoline equivalent gallon. One gasoline equivalent gallon = 1.4 gallons of E85, 1.74 gallons of M85, and 1.03 gallons of E10.
2. Since alternative fuels contain less energy per gallon, more gallons are used to travel the same distance. GEG-adjusted taxes would take this into account.

Table 8-2
Results of Ethanol Cost Analyses

Ethanol Scenarios	Ethanol Annual Volumes (gallons 100% alcohol)	**Sold as E10**		**Sold as E85**			
				With Existing Taxes		With GEG-adjusted Taxes (2)	
		Low Pump Price ($/GEG)	High Pump Price ($/GEG)	Low Pump Price ($/GEG)	High Pump Price ($/GEG)	Low Pump Price ($/GEG)	High Pump Price ($/GEG)
E1a&b. Ethanol Imported - Containers	6,000 170,000 +	$1.71 $1.68	$1.77 $1.71	$3.48 $3.49	$5.85 $3.95	$3.32 $3.33	$5.69 $3.79
E2a&b. Ethanol Made from Waste on Oahu	7,000,000 30,000,000	$1.53 $1.52	$1.65 $1.63	$1.72 $1.59	$3.53 $3.30	$1.56 $1.43	$3.37 $3.14
E3a&b. Ethanol Made from Molasses on a Neighbor Island and Shipped to Oahu	1,001,075 3,003,225	$1.67 $1.58	$1.73 $1.61	$3.43 $2.42	$4.41 $3.07	$3.27 $2.26	$4.25 $2.91
E4a&b. Ethanol Made from Sugarcane on Oahu	7,000,000 30,000,000	$1.56 $1.55	$1.70 $1.68	$2.08 $1.94	$4.13 $3.91	$1.92 $1.78	$3.97 $3.75
E5. Ethanol Made from Sugarcane on a Neighbor Island and Shipped to Oahu	60,000,000 100,000,000	not calculated see note (1)	not calculated see note (1)	$2.28 $2.28	$4.14 $4.04	$2.12 $2.12	$3.98 $3.88

Notes:

1. Total statewide gasoline demand is less than 400 million gallons per year; ten percent would be less than 40 million gallons.
2. Since alternative fuels contain less energy per gallon, more gallons are used to travel the same distance.GEG-adjusted taxes would take this into account.

Projected high-level ethanol blend (E85) costs at the pump range from a high of $5.85 per gasoline equivalent gallon, with the highest costs seen in the containerized import scenario (E1) at very small volumes, to a low of $1.59 in the scenario of production from MSW and use on Oahu (E2a). With adjustment of taxes on the basis of energy content, high-level ethanol blend costs at the pump range from a high of $5.69 to a low of $1.43 per gasoline equivalent gallon.

Figures 8-1, 8-2, and 8-3 display information from Tables 8-1 and 8-2, as well as an average price for regular unleaded gasoline in Honolulu (DBEDT, 1993), in graphic form.

It is readily apparent (See Figures 8-1 and 8-2) that high level alcohol blends (M85 and E85) are more costly than gasoline on a GEG basis. Lower-level alcohol blend (E10) scenarios (see Figure 8-3) have projected costs which are much closer to current gasoline prices.

Figure 8-1
M85 Scenarios: Projected Costs

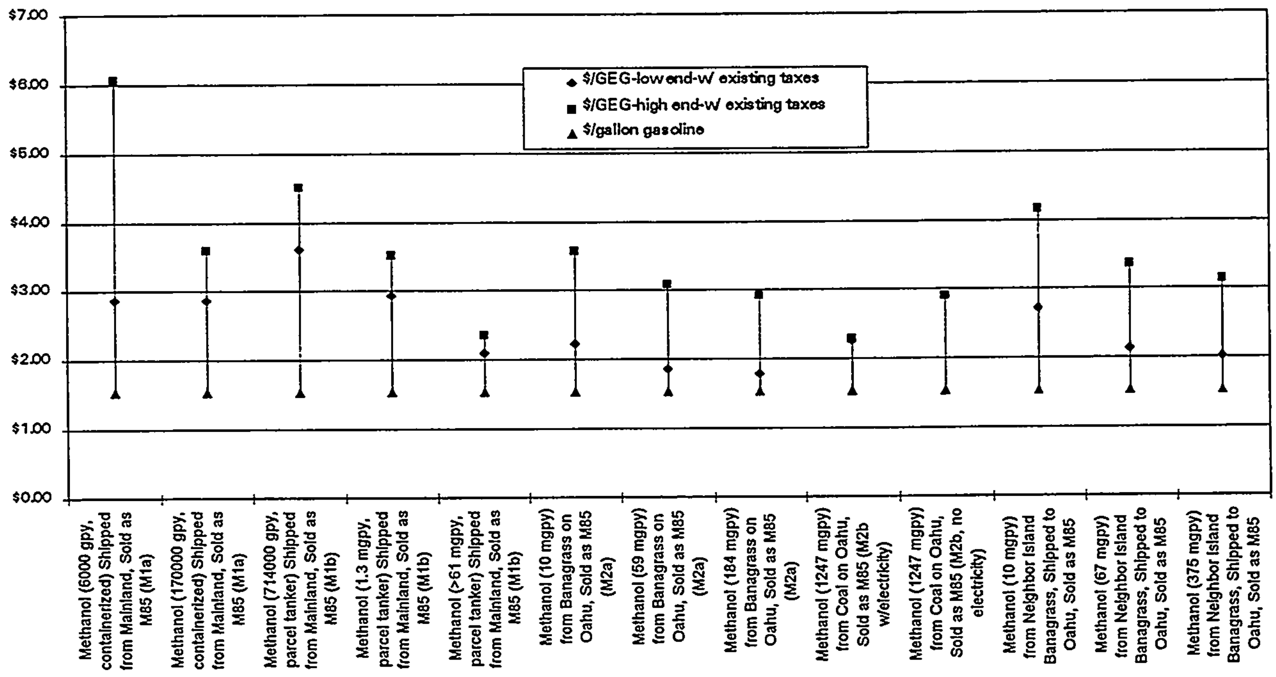


Figure 8-2
E85 Scenarios: Projected Costs

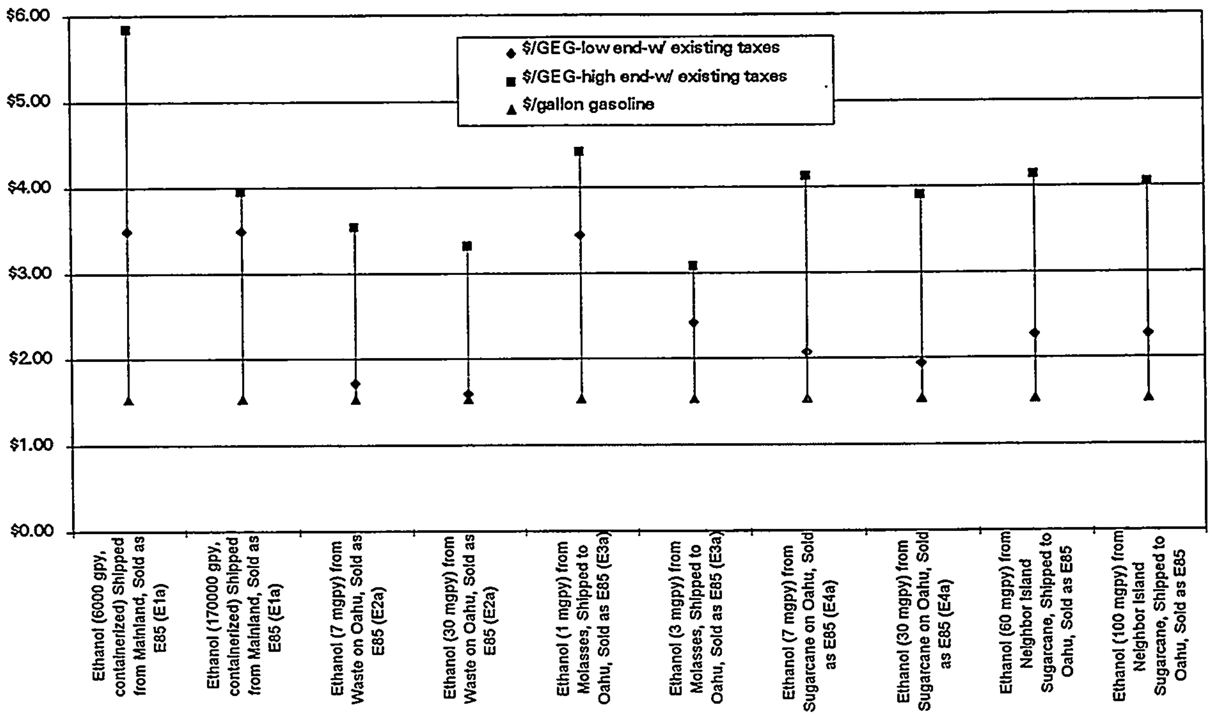
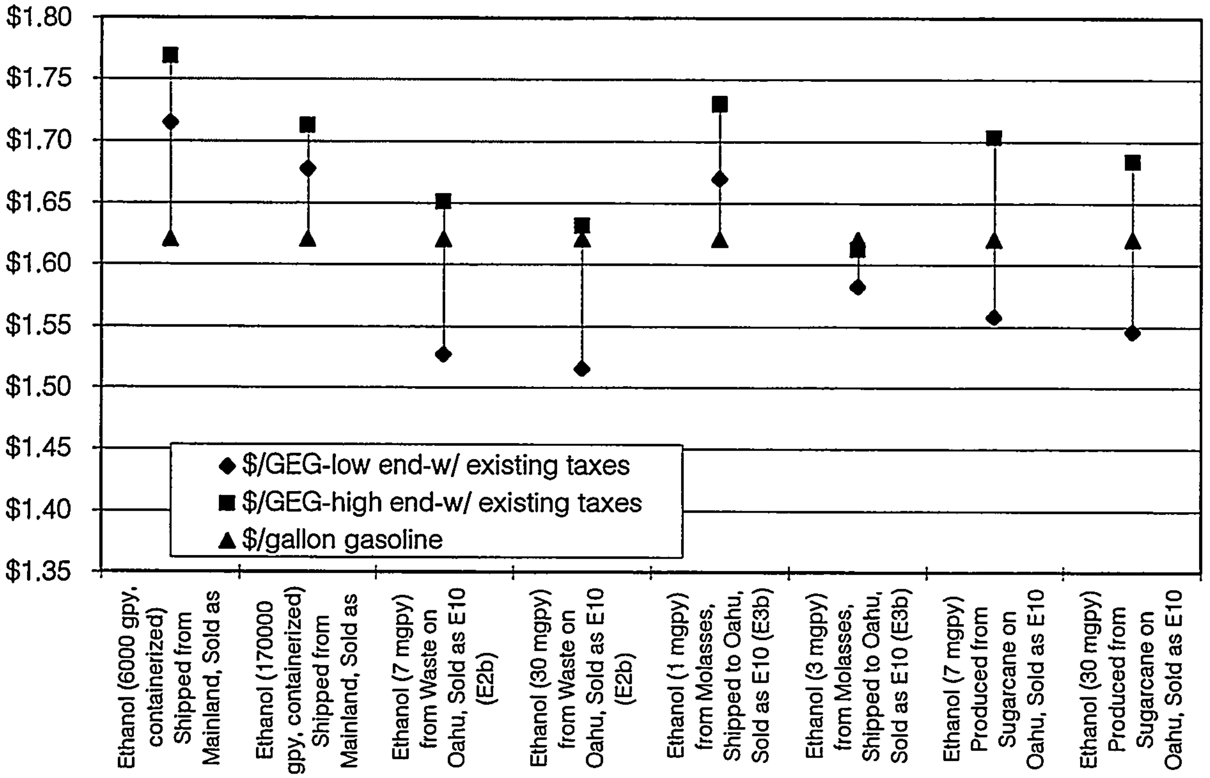


Figure 8-3
E10 Scenarios: Projected Costs



The lowest cost alcohol fuel scenario is the low cost case of ethanol from waste on Oahu. It is important to note that the spread between the low cost case and the high cost case of this scenario is quite wide, indicating that several major cost items are uncertain. In this case, key high cost elements are newly-developed (and as yet uncommercialized) processing technology and federal alcohol fuel tax credits. Cost components' influence on scenario results are discussed in the next section. The amount of ethanol from this feedstock (and therefore the amount of ethanol at this price) is limited to the quantity of waste material available.

Figure 8-4 shows the maximum alcohol production possible from the various feedstocks. Production is given in percent of transportation energy consumed in the ground sector statewide in 1990 (see Chapter 2). Based purely on the acreage of good agricultural land on which energy crops might be grown (disregarding the costs and vehicle compatibility requirements of such an endeavor), enough ethanol or methanol could be produced from locally-grown materials to supply all of the ground sector transportation energy in the state.

Figure 8-5 superimposes projected costs for the high-level methanol (M85) and ethanol (E85) blend scenarios on Figure 8-4 to show pump price ranges as well as the maximum available alcohol for various scenarios. Pump price, shown on the right axis, is in dollars per GEG at the pump for 85 percent alcohol blends. Volume, shown on the left axis, is in percent of 1990 transportation energy in the ground sector. Evaluation of alternative fuel scenarios, or

Figure 8-4

Energy Potentially Available from Alcohol Fuels in Hawaii

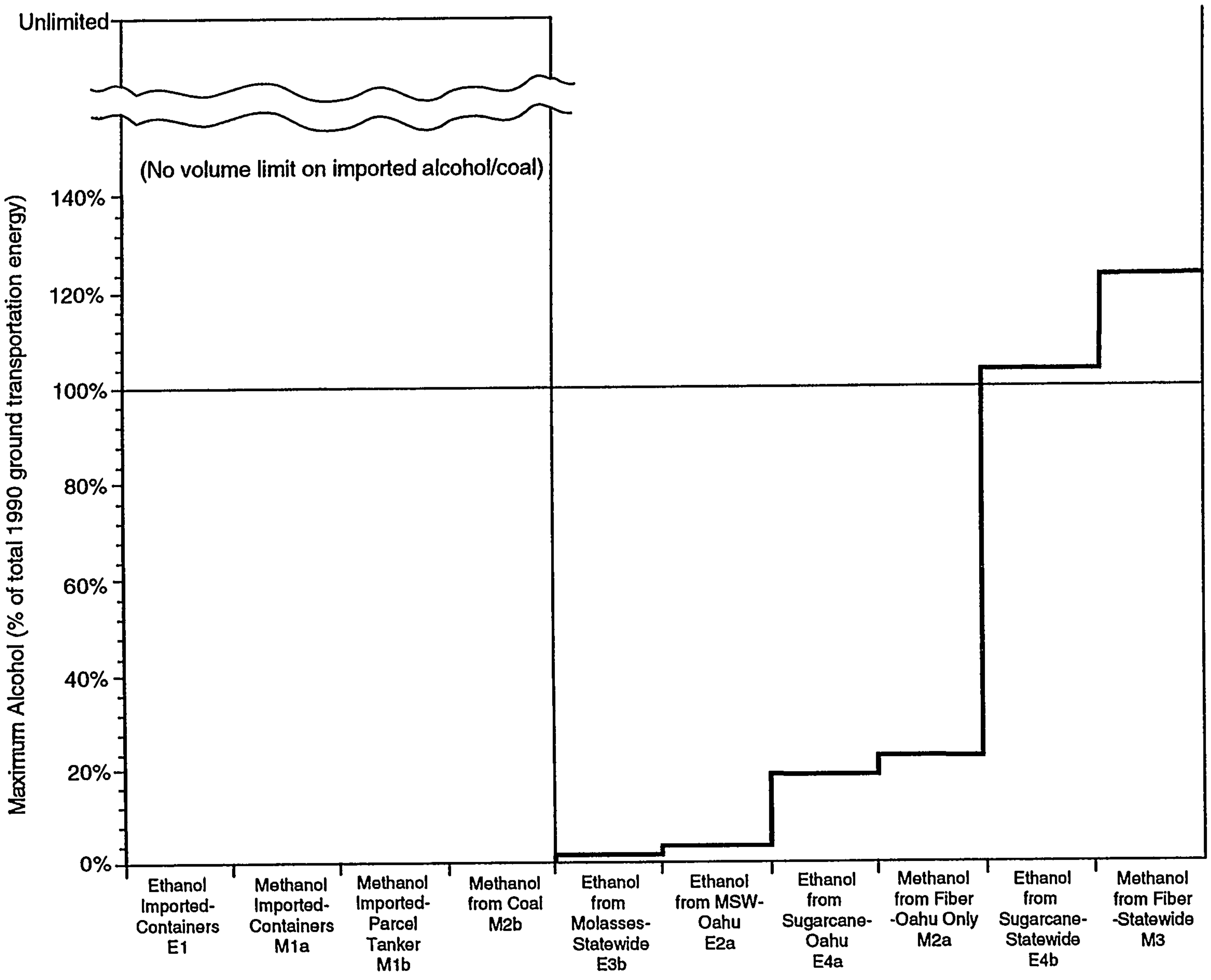
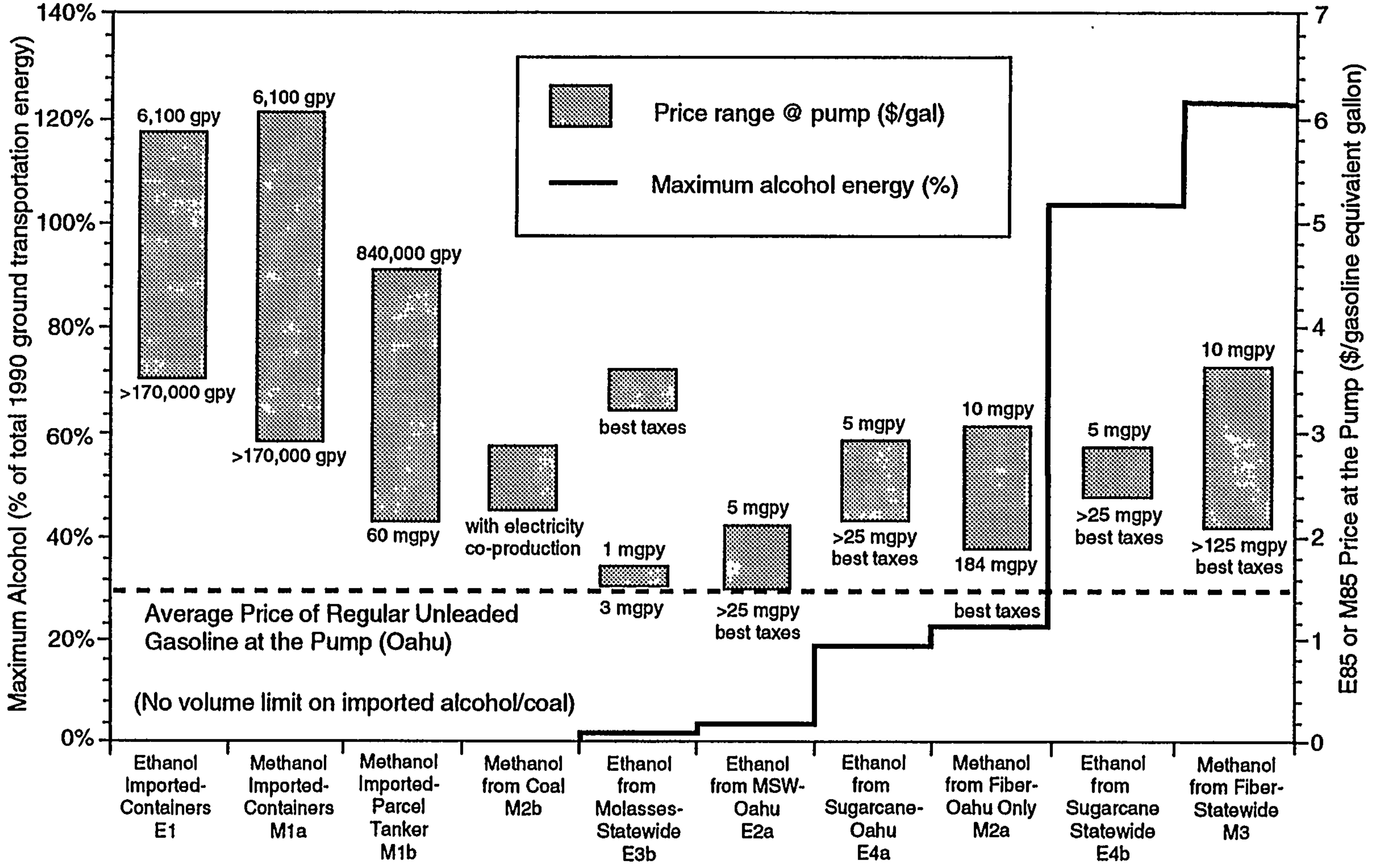


Figure 8-5

Energy Available and Gasoline Equivalent Pump Price Range of M85 and E85 Fuels in Hawaii

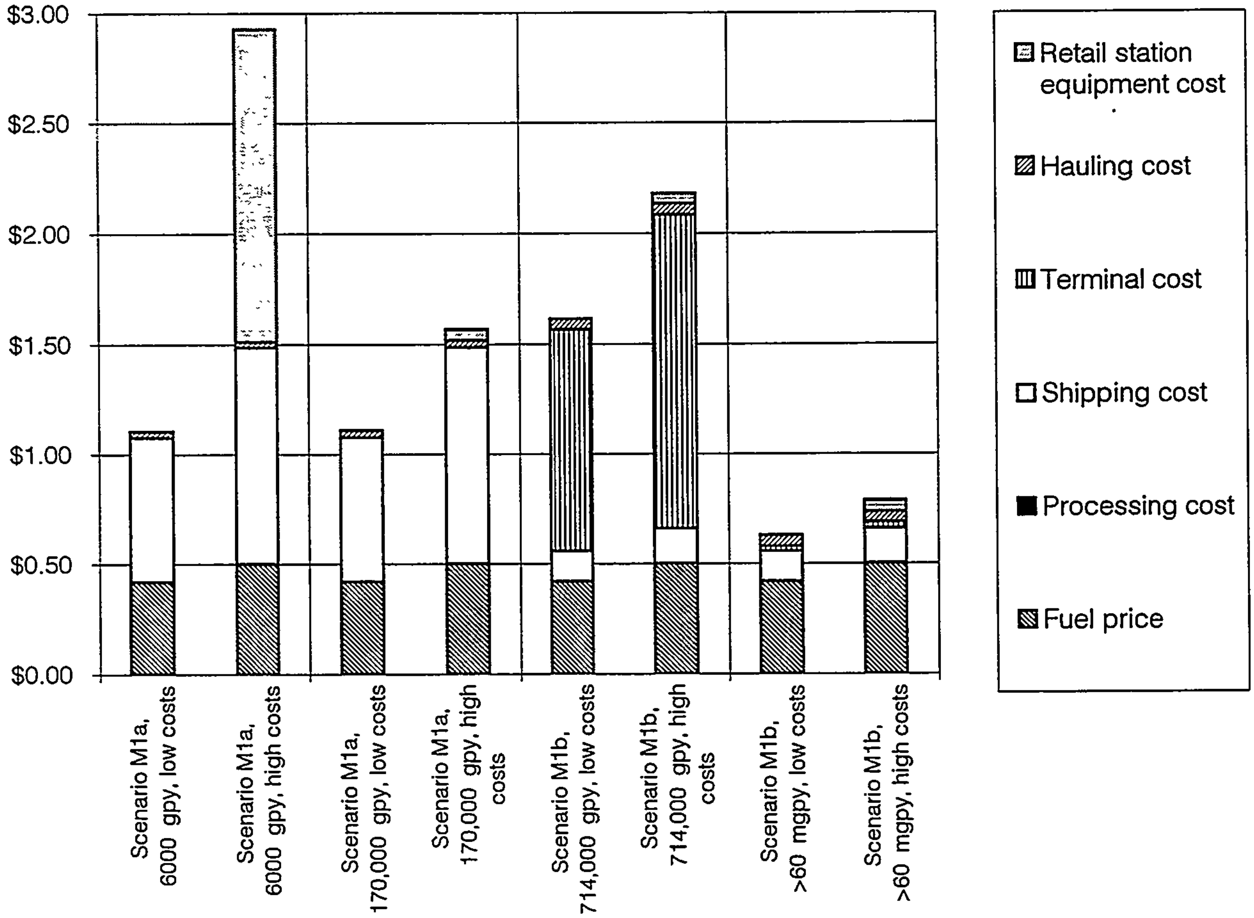


combination of scenarios, must consider both cost and availability at different levels of demand.

8.2.4.1 IDENTIFICATION OF KEY COST ELEMENTS AND UNCERTAINTIES

The cost analyses allow identification of key cost components and uncertainties. Although site-specific analyses are beyond the scope of this study, the analysis tools developed may be used for preliminary estimates of fuel costs for specific sites and conditions. Also, as key cost elements change, the impact of these changes on the bottom line may be evaluated. Selected "high cost" and "low cost" scenarios, shown in Figures 8-6 and 8-7, illustrate this type of comparison.

Figure 8-6
Examples of Key Cost Components And Uncertainties For Selected Methanol Import Scenarios



In a container import scenario (see Scenario M1a in Figure 8-6), the high cost case is quite high at very low import volumes, but decreases with increasing sales volume up to about 200,000 gpy. As may be seen by comparing the second and fourth bars in the graph, this is because, per gallon of alcohol sold, the capital costs associated with offering alcohol fuel at a retail station (installing alcohol tanks and dispensers, for example) decreases as the volume of alcohol sold increases (the low cost cases, represented by the first and third column in Figure 8-6, assume that existing tanks are used; therefore, there are no new facility installation costs). At about 200,000 gpy throughput, the retail margin falls to 4 cents per gallon, and therefore the pump price of alcohol could only fall by a few more cents per GEG if the throughput increased. At this volume, it is assumed that it would be more worthwhile to increase the number of stations offering alcohol than to further increase a single station's throughput. This is the only scenario in which the total annual demand volume is assumed to be in a low enough range that retail station costs vary with the annual demand volume. In all other scenarios, the number of stations is chosen such that annual throughput roughly equals 200,000 gallons, subject to a maximum number of stations of 300, about the number of retail stations on Oahu (Zane, 1992).

In the parcel tanker scenario (see Scenario M1b in Figure 8-6), the lower per gallon cost of shipping methanol in bulk rather than in 6100 gallon tanks is offset by the added cost of constructing a terminal to receive bulk shipments. At low annual demand volumes (i.e. the 714,000 gpy scenario) this added cost is very high. As the throughput volume increases, the terminal costs per gallon fall to one to a few cents per gallon. The lowest cost case (over 60 mgpy) results in greatly reduced terminal costs.

The impact of terminal cost is also apparent in scenarios which involve production of alcohol fuel on one island and shipment between islands (see scenario M3 in Figure 8-7).

The projected costs of biomass-derived alcohols are primarily influenced by feedstock price, processing cost, plant scale, and, in scenarios which include barging between islands, shipping and terminal-related costs. Whether the plant is assumed to be able to take full advantage of the alcohol fuel tax credit, shown as part of the "processing cost," has a very large effect on the final pump price. The low cost cases include low processing costs in addition to full use of the tax credit; the high cost cases include high actual processing costs and do not take advantage of the tax credit. The magnitude of individual cost elements may be seen in the cost tables in Appendix A-3.

Fuel taxes are another important element in projected fuel costs at the pump. Under current state and County fuel tax laws, motor fuels are taxed on a per-gallon basis. This puts most alternative fuels at a disadvantage on a cost-per-mile basis, since alternative fuel vehicles use more gallons to travel the same distance. The effect of this on the projected methanol costs is shown in Figure 8-8.

Figure 8-7
Examples of Key Cost Components And Uncertainties For Selected Methanol Production Scenarios

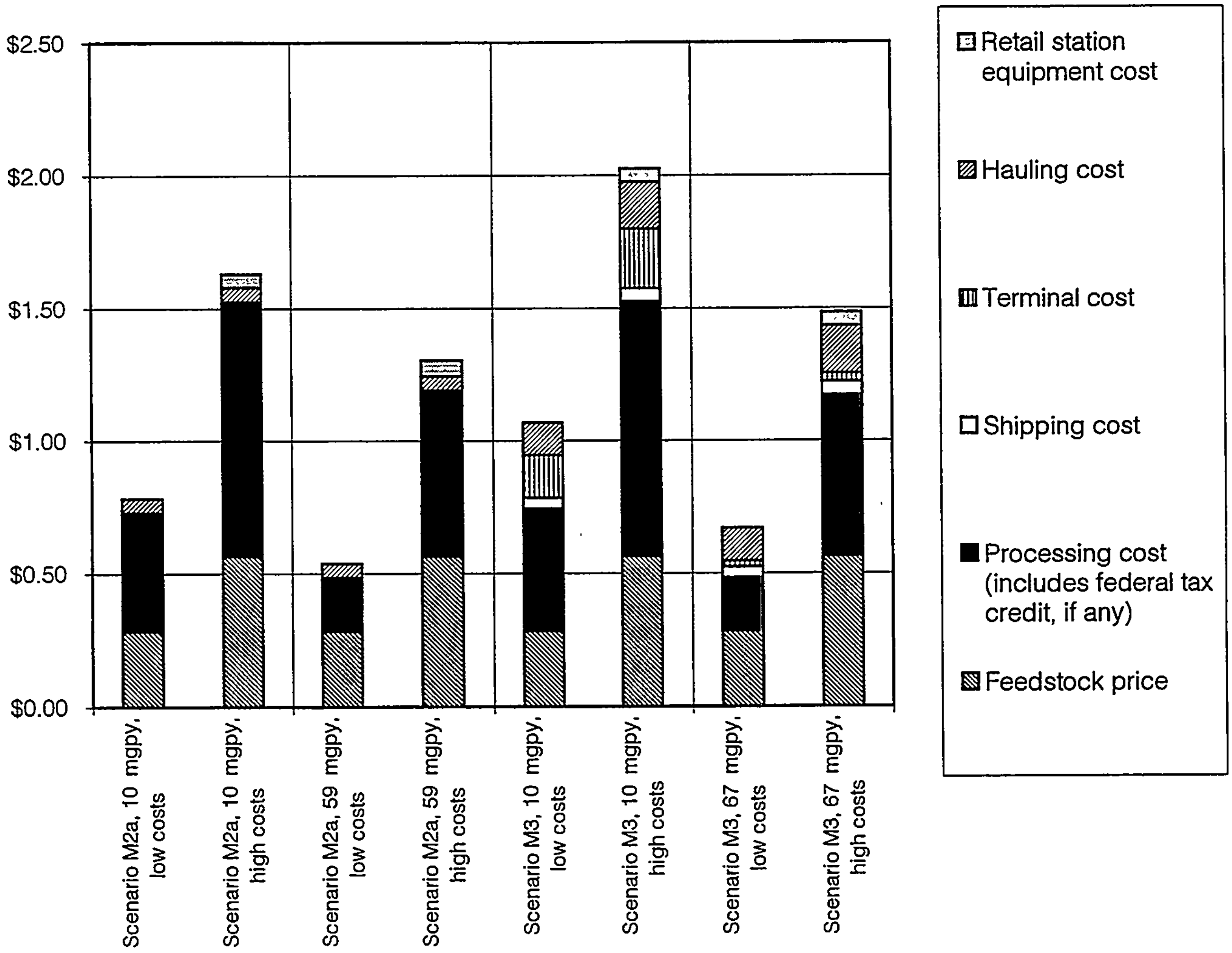
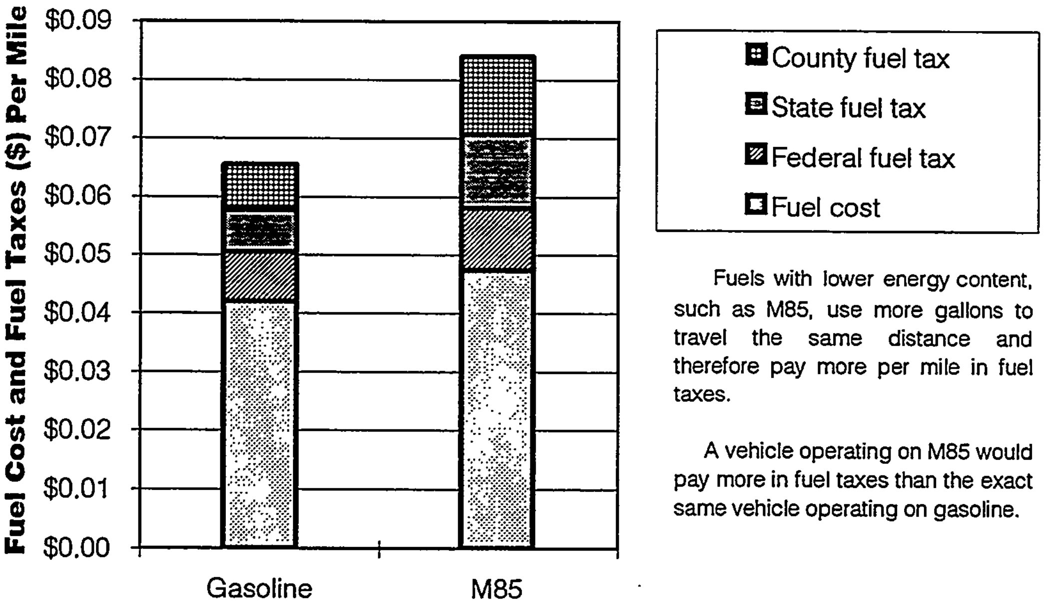


Figure 8-8
Fuel Taxes are Higher for M85 Than for Gasoline



Fuels with lower energy content, such as M85, use more gallons to travel the same distance and therefore pay more per mile in fuel taxes.

A vehicle operating on M85 would pay more in fuel taxes than the exact same vehicle operating on gasoline.

As cost elements change (for example, changes in tax laws, improved biomass yields resulting in reduced feedstock costs, availability of lower-cost feedstocks and/or by-products of other agricultural crops, increased alcohol yields, reduced equipment and processing costs, or even reduced financing costs), or as specific information allows assumptions to be fine-tuned (for example, current assumptions contain logistics of tank truck drivers spending 4 to 7 hours per round-trip to Hilo Harbor and quite a bit of back-and-forth from Honolulu Harbor to Barbers Point), the impact of those changes may immediately be evaluated simply by changing the appropriate values in the cost estimation model.

8.2.5 COMPETITIVENESS OF IMPORTED ALCOHOLS

8.2.5.1 METHANOL

Mainland methanol is derived from natural gas and thus costs considerably less at the point of production than is projected for biomass-derived methanol produced in Hawaii. Methanol imported in bulk has the potential to be competitive with methanol produced in Hawaii, depending on the local production scenario (see Figure 8-1). However, if methanol produced in Hawaii were to be subsidized at the point of production by the state to be competitive with gasoline at the pump, imported methanol would not be able to compete.

The conclusion that imported methanol would not be competitive with methanol produced locally in Hawaii from biomass is valid only for the scenario considered. Another possibility might apply during a mature program in Hawaii with a fairly high demand for alcohol fuel. If methanol prices in the American continents were in a period of weakness, and higher shipping volumes to meet Hawaii demand could allow dedicated tanker shipments, it is conceivable that imported methanol could approach the prices of methanol produced locally. This possibility deserves some attention in the detailed design of any incentive program.

How likely is it that imported methanol could compete with local methanol receiving incentives? Figure 8-9 shows the history of spot methanol prices in the Texas Gulf (in 1987 constant dollars). There have been several recent periods during which methanol was available at prices in the neighborhood of 30 cents per gallon. In 1972, methanol was at less than 20 cents for a brief period. These low prices would appear to correspond to variable production costs (including cost of feedstock, operating and maintenance, and shipping), at least based on recent cost analyses.[10] In these periods, producers evidently were willing to sell at variable costs for a period of time to avoid costs of mothballing plants and laying off employees, and perhaps to meet commitments to purchase feedstock gas.

If another "methanol bust" episode of this type occurred in the future, it is possible that producers of methanol from natural gas might attempt to sell into a Hawaii market. However, this appears extremely unlikely. Additional shipping costs to Hawaii, even in moderate-sized tanker ships (as compared with parcel tankers) bringing methanol from Canada, Central America, South America, or South East Asia or even from more distant locations, combined with a 20 or 30 cent methanol price, would result in a landed methanol price in Hawaii of about 40 cents per gallon of M100, which would be $0.28 per gallon less than the projected cost for methanol produced from large-scale fiber-to-methanol plants in Hawaii.

Although there is always some risk of competition for a large market, it does not appear likely that methanol produced from natural gas would compete in Hawaii with gasoline or with locally-produced methanol that received local incentives sufficient to make it competitive with gasoline.

8.2.5.2 ETHANOL

While production costs vary with the cost of labor, plant scale, market price, revenues from by-products, and other factors, the cost of ethanol produced in Hawaii from low-cost biomass feedstocks is projected to be similar to ethanol produced from corn on the mainland. Since mainland ethanol is mostly produced in the midwest, the cost of transport by truck or rail to the west coast of the U.S. or Canada[11] would be added to the costs of overseas shipment to Hawaii. Thus, ethanol shipped from the mainland would be disadvantaged compared to locally-produced ethanol as both trucking and shipping costs would be added to the relatively similar production costs. Fortunately, an ethanol program need not depend on imports in the early years (as a methanol program would) because relatively efficient small scale ethanol plants in the 1 to 5 million gpy range could be brought on-line relatively quickly.

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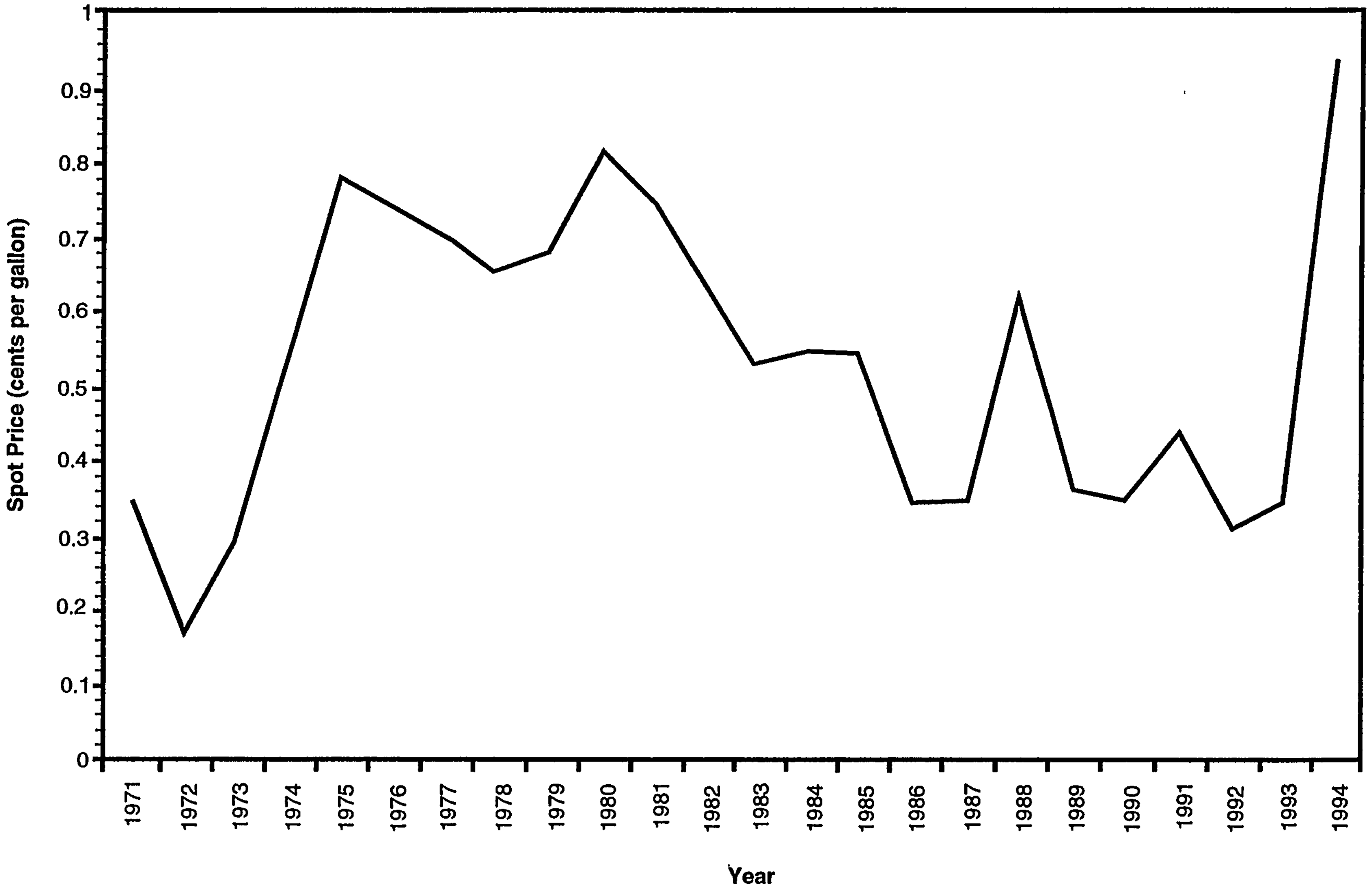
[10] See for example, Bechtel, Inc., San Francisco, California, California Fuel Methanol Cost Study, Final Report, Vol. II (Managing Sponsor: Chevron USA, San Francisco, California), December, 1988, and Acurex Corporation, Mountain View, California, Methanol as a Motor Fuel: Review of the Issues Related to Air Quality, Demand, Supply, Cost, Consumer Acceptance and Health and Safety, California Energy Commission, Sacramento, California, P500-89-002, April, 1989.

[11] If the ethanol was shipped from a U.S. Port, The Jones Act would require shipping under U.S. flag, which could be even more expensive.

Figure 8-9

History of Methanol Average Annual Spot Price in the U.S. Gulf



8.2.6 CONCLUSIONS OF THE ALCOHOL COST ANALYSES

M85 and E85

Considering all cases of alcohol in 85 percent blends (M85 or E85), only ethanol (E85) produced locally from MSW, under favorable conditions (i.e. the "low pump price" case), could be viewed as competitive with current gasoline prices at the pump.[12] If adjustments were to be made to fuel taxes on the basis of energy content, methanol (M85) from banagrass is also projected, under favorable conditions, to be competitive with current gasoline prices at the pump. In all other scenarios, 85 percent alcohol blends are more costly at the pump than even premium gasoline (about $1.73 per gallon).

Changes in a number of factors may affect costs. The impact of such changes may be calculated using the analysis tools developed in this project; scenarios may be run for a variety of assumptions. Policies which affect any of the cost elements may be tested for each of the scenarios.

E10

Due to E10's higher octane level than regular unleaded, it may be most appropriate to compare E10 prices to premium (or mid-grade) gasoline where, in fact, it appears that E10 could compete at the pump.[13] As with M85 and E85, cost projections are sensitive to changes in any number of assumptions and cost factors; the impact of such changes may readily be calculated using tools developed in this project.

8.3 BIODIESELS

The possible feedstocks for local production of biodiesels and the cost implications of each were discussed in Chapter 5. The most cost-effective option was production of biodiesel fuel from waste oil from, for example, restaurants. A representative of Interchem Industries, Inc. estimates that waste oil could be converted into biodiesel fuel at a price of about $1.50 per gallon of finished product (Ayers, 1993). If used in diesel vehicles at a twenty percent blend (80 percent petroleum-based diesel), this would add a cost of about 15 cents per gallon to the price of diesel fuel.[14] As described in Chapter 5, waste oil is estimated to be able to provide only 500,000 to 700,000 gallons per year (Ayers, 1993). This is less than 1 percent of the total diesel fuel currently consumed in the ground sector.

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[12] It may be expected that, if alcohol fuels were to actually compete with gasoline on the basis of price, gasoline pump prices would decrease in response to the new competition.

[13] About 42 percent (or 160 million gallons) of the gasoline sold in Hawaii in 1992 was mid-grade or premium (Energy Information Administration, 1992). If E10 were to replace this volume of mid-grade and premium gasoline sales, this would provide a market for about 16 million gallons of ethanol per year. If E10 were to replace all sales of gasoline, the Statewide market for ethanol would be about 38 mgpy.

[14] This estimate assumes a diesel rack price of 73 cents per gallon based on 1993 data and no fuel economy change due to use of the biodiesel blend.

Tropical oil crops grown in Hawaii include macadamia nuts and kukui nuts. Oils from these crops currently sell into high-price markets such as the cosmetic industry. The wholesale price for macadamia nut oil is about 15 to 18 dollars per gallon (Hawaii Kukui Nut Company, 1993),[15] kukui nut oil is even more costly. Considering that this is over ten times the typical price of soybean oil, it seems clear that these crops are not logical candidates for biodiesel feedstock. Information allowing an analysis of locally-produced biodiesel using the Chinese tallow tree, a potentially promising high-yield crop (discussed in Chapter 5) is not readily available (Boom, 1993).

Other potential feedstocks include soybeans, peanuts, or sunflowers. If these crops were to be grown in Hawaii at sufficient scale, biodiesel could be manufactured in Hawaii and the biodiesel price would be similar to the mainland price of $2.50 per gallon (Ayers, 1993). This price would result in an incremental price increase of about 35 cent per gallon of twenty percent biodiesel.

8.4 ELECTRIC POWERED VEHICLES

The phrase "electric vehicle technology" encompasses a very wide range of vehicle design (see Chapter 4). Furthermore, electric vehicle technology is developing at a rapid rate; a great deal of research is underway to optimize battery technology and fuel cell technology to maximize performance and bring costs down to an acceptable level. Research on other components of electric vehicle drive systems is ongoing as well. Research efforts extend to vehicle bodies: unconventional carbon fiber bodies are being considered as a lightweight alternative to traditional automotive materials to extend electric vehicle range.

Because electric vehicle development encompasses so many technologies, most of which may not mature for a number of years, and because, further, the most commercially-auspicious technologies have not yet become apparent, providing typical costings for electric vehicle operation is difficult. Most of the cost data currently available from electric vehicle demonstrations is not representative of even near-future electric vehicle technology. For example, the majority of the available data is for the limited-production Vehma-Conceptor G-Van (at a very high vehicle sales price of $55,000 to $60,000 per van) which is out of production and which Vehma-Conceptor and Electric Power Research Institute (EPRI) do not plan to reintroduce. Furthermore, field data varies widely with the vehicle and the application. For all of these reasons, it is very difficult, if not impossible, to construct representative costings of electric vehicle use in Hawaii upon which it would be appropriate to base energy strategy recommendations. Such data is expected to come out of the Hawaii Electric Vehicle Demonstration Program (HEVDP) (see Chapter 4). Therefore, the electric vehicle costs estimated in this study should be viewed as very preliminary. This study provides brief discussions of some of the main elements of battery-electric vehicle life-cycle costs and purchase prices for a number of currently available models.

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[15] For contracts for more than 11,000 pounds, prices may be lower and are individually negotiated.

The cost of operating a battery-electric vehicle involves several elements. Key cost-related elements include:

- initial vehicle purchase;
- battery replacement;
- maintenance/parts;
- electricity/recharging; and
- federal, state, and local incentives.

8.4.1 INITIAL VEHICLE PURCHASE

Electric vehicle (EV) prices span a very wide range. Some of the EVs recently or currently available are very expensive. For example, the Vehma-Conceptor G-Van as mentioned above was sold for $55,000 to $60,000, and the currently available Chrysler electric version of the Dodge Caravan/Plymouth Voyager is available for approximately $100,000. Another very recent example comes from Santa Clara County, California, which agreed in March of 1994 to acquire 8 modified electric Geo Prizms for about $41,500 each (San Francisco Chronicle, 1994). Relatively inexpensive EVs are available as well, typically from small-volume manufacturers. For example, the Suntera Sunray, manufactured in Hawaii, is projected to be priced at $12,000.

The major automobile manufacturers are readying their EV technologies to meet the California requirement that 2 percent of the vehicles offered for sale in the state beginning in 1998 be zero-emission vehicles. The big three have been cooperating in order to meet this requirement, forming industry consortia to further electric vehicle technology. Regardless of the large amount of effort being focused on developing commercial electric vehicles, the major manufacturers still anticipate that electric vehicles will be much more costly to produce in the early years than conventionally fueled vehicles. Ford anticipates that the electric vehicles offered initially in 1998 will present Ford with a $10,000 loss per electric vehicle sold if the vehicles are priced to be competitive in the marketplace (Nichols, 1993). Ford does anticipate, based on prior experience introducing new technologies, that this initial high cost will "wear off" over the next ten years so that in the 2008 timeframe, electric vehicles would be competitively priced and the manufacturer would not take a loss on the sale of the vehicle (Nichols, 1993). Table 8-3 lists purchase price information as available for a number of currently available EV models.

Table 8-3
Electric Vehicle Purchase Prices for Selected Models

Manufacturer	Model	Description	OEM*	Range (miles) @30 mph	Price
B.A.T. Technology	Geo Metro	Small auto	N	80	$15,900
B.A.T. Technology	Ford Ranger	Small truck	N	80	$24,100
California Alternative Propulsion Company	Selectable Drive Hybrid	Small truck	N	70	$20,000
California Electric Cars, Inc.	Big Sur	Jeep	N	120	$21,900
California Electric Cars, Inc.	Monterey	Small auto	N	150	$35,000
Chrysler	Minivan	Minivan	Y		$100,000
Domino Cars, U.S.A.	Minilight	Small auto	N	93	$21,000
Eco-motion	Ion-1	Small auto	N	80	$15,995
Elcat	Elcat Cityvan	Minivan	N	65	$20,000
Green Motorworks, Inc.	Kewet El-jet	Small auto	N	40	$13,000
Green Motorworks, Inc.	Speedster	Small auto	N	60	$32,000
Herb Adams, V.S.E.	Jackrabbit	Small auto	N	110	$24,000
Sebring Auto-Cycle, Inc.	ZEV-Colt	Small auto	N	60	$24,000
Solectria	Force (PbAcid)	Small auto	N	90	$26,000
Solectria	Electric Pick-up	Small auto	N	80	$40,000
Solectria	Force (NiCad)	Small auto	N	130	$60,000
Specialty Vehicle Manufacturing Corp.	Model 3122	Trolley	Y	50-75	$140,000
Specialty Vehicle Manufacturing Corp.	Model 4122	Shuttle	Y	50-75	$109,000
Specialty Vehicle Manufacturing Corp.	Model 5122	Shuttle	Y	50-75	$130,000
Specialty Vehicle Manufacturing Corp.	Model 5122	Bus	Y	50-75	$140,000
Suntera	Sunray	Small auto	Y	87	$12,000
US Electricar	Geo Prizm	Small auto	N	NR	$41,500
VoltAge, Inc.	Voltzvogon	Small auto	N	45	$11,500

*Vehicles manufactured by Original Equipment Manufacturers (OEMs) versus conversion/retrofit technologies marked "Y".

8.4.2 BATTERY REPLACEMENT COSTS

Battery costs are significant in the overall cost of operating an EV. For example, the lead-acid battery pack for the limited-production G-Van must be replaced every 30,000 miles at a cost of $7,000 to $8,000 (McCoy and Lyons, 1993b). General Motors estimated that batteries for the Impact will cost about $1,500 to replace every 20,000 to 25,000 miles (McCoy and Lyons, 1993b). Considering battery cost as a component of fuel cost for the moment, this is a substantial price to pay. To draw a simple comparison, a recent model year car with an assumed fuel economy of 30 miles per gallon would consume about 830 gallons of fuel to travel 25,000 miles. If gasoline cost $1.50 per gallon, the cost of fuel for 25,000 miles of travel in a conventional car would be about $1,250. For the Impact, 25,000 miles of travel would cost $1,500 for the batteries alone, on top of the cost of purchasing electricity to recharge the batteries.

One useful way to look at battery costs is in terms of dollars per kilowatt-hour (kWh). A kilowatt-hour, like British thermal unit (Btu), is a unit of energy. The kWh supplied by a battery pack is related to the vehicle range: as the kWh capacity per charge increases, so does the vehicle range. For example, an EV with a 15 kWh battery pack and an energy economy of 0.25 kWh per mile would have a range of 15/0.25 = 60 miles between recharges. Table 8-4 shows projected costs of various battery technologies as well as the cost criterion adopted by the U.S. Advanced Battery Consortium in cost per kWh (The Lewis Center for Regional Policy Studies, 1993).

Table 8-4
Projected Battery Costs

Battery Type	Projected Cost ($/kWh)
Lead-Acid	70-100
Nickel Iron	160-300
Nickel Cadmium	300
Sodium Sulfur	100+
Lithium Iron Sulfide	100-200
Zinc Bromide	100-300
Nickel Metal Hydride	200
USABC Mid-Term Criterion	150
USABC Long-Term Criterion	100

Source: The Lewis Center, 1993.

EV battery technology is the focus of a great deal of research and development. In addition to the relatively mature lead-acid technology, several battery technologies are being examined for use in EVs, including sodium-sulfur, nickel-iron, and nickel cadmium. Research into recharging methods is underway, as well, and significant advances are being made. Recently the world record for miles traveled by an EV in a 24-hour period was shattered due to a new charging technique allowing 16 kWh of charging in less than 19 minutes. Such speed will increase the consumer appeal of EVs, but more importantly for cost reduction, the charging technique is also much easier on the battery. The new technique, which involves a computer-controlled charging algorithm developed by Electronic Power Technology, Inc., is expected to result in a much longer battery life (San Jose Mercury News, 1994). Continued improvements in battery and recharging technology should result in substantial cost savings in the future.

8.4.3 ELECTRICITY COSTS

The cost of electric power to recharge EVs is another key factor in evaluating the cost of operating an EV. By way of example, the Hawaiian Electric Company (HECO) general service (Schedule "G") rate is 10.5763 cents per kWh (Waller, 1993). For the G-Van, with an average energy consumption of 1.44 kWh/mile (Waller, 1993), this rate would result in a per mile electricity cost of about 15 cents per mile. This is relatively high; for a gasoline van achieving 15 miles per gallon, a 15 cent per mile fuel cost would imply a gasoline price of about $2.30 per gallon. However, EV development is resulting in increasingly efficient vehicles. Greater efficiency brings electricity costs per mile well below gasoline prices. For example, a small, efficient EV might consume 0.25 kWh per mile. At the Schedule "G" rate, this would result in a per mile electricity cost of 2.6 cents per mile, equivalent to gasoline at $0.79 per gallon for a 30 mile-per-gallon car. Furthermore, the Schedule "G" rate is not necessarily the rate that would apply for EV charging. HECO is currently developing special EV rates (Waller, 1993). Given HECO's interest in meeting minimum load requirements, it might be conjectured that the rate would be designed to encourage EV use, at least for off-peak charging.

As was discussed in Chapter 4, in order for EV use to improve Hawaii's energy security, electric power would need to be generated from non-petroleum sources such as coal, biomass, wind, geothermal energy, and solar energy. In Chapter 7, the production of electricity from biomass is discussed and cost estimates are derived for feedstock at $50 per ton. Electricity costs out of the plant in cents per kWh range from 8 cents per kWh for large plant to 12.5 cents per kWh for a small plant. Furthermore, the National Energy Policy Act of 1992 (EPACT) includes a tax credit for renewable electricity production (limited to wind and closed-loop biomass) of 1.5 cents (in 1992 dollars) per kWh. An assessment of all the renewable energy resources will be important for evaluating the costs and benefits for Hawaii of a program promoting widespread electric vehicle use; such an effort is ongoing in Project 3 of the Hawaii Energy Strategy.

Finally, the cost of recharging infrastructure will not be large in many cases, depending on type of station. The California Energy Commission (CEC) estimates that installing a typical recharging site will cost about $300 (CEC, 1991). Amortizing such a low cost will not appreciably affect the price of electricity delivered to a vehicle.

8.4.4 MAINTENANCE COSTS

More data will be needed to properly evaluate EV maintenance costs. Furthermore, experience with the introduction of new technologies shows that maintenance costs will drop as the technology matures. In 1991 the Arizona Public Service Company (APSC) collected data on maintenance and labor costs for 11 electric vehicles that the APSC was operating. Table 8-5 shows these costs for electric vehicles compared with counterpart gasoline vehicles also operated by the Arizona Public Service Company (McCoy and Lyons, 1993b).

The Hawaii Electric Vehicle Demonstration Project will produce valuable data on electric vehicle maintenance for a wide range of electric vehicle types. The demonstration program will establish a conversion, service, and maintenance center in Honolulu's Kaka'ako District. This center will provide personnel training as well as vehicle service.

8.4.5 LIFE CYCLE COSTS

Table 8-6 shows examples of life cycle cost analyses for electric vehicles. The best information is that the range of estimates of the cost of operating an electric vehicle is as wide as the range of EV technology currently available. Furthermore, electric vehicle cost analyses are hampered by immature technologies and lack of data. Life cycle cost analyses does not take into account financial incentives for electric vehicles which are a part of EPACT. These incentives are described elsewhere in this report and include a tax credit equal to 10 percent of the costs of purchasing an electric vehicle up to $4,000, and a tax deduction for electric vehicle refueling property up to $100,000 per refueling site.

Table 8-5
Fleet Vehicle Maintenance and Labor Costs at Arizona Public Service Company

Vehicle Type	Maintenance and Labor Cost[1] $/Mile	
	Electric	**Gasoline**
Electric Escort Sedan	.199	N/A[2]
Electric G-Van	.286	N/A
Electric, all sedans	.205	N/A
Gasoline compact sedan	N/A	.171
Gasoline, full-size sedans	N/A	.471
Gasoline full-size van	N/A	.314

Source: Arizona Public Service Company.
Notes:
1) Labor cost at $23/hour.
2) Vehicle type not applicable to energy source.

8.5 PROPANE

Propane, or liquefied petroleum gas (LPG), has been used in the transportation sector for many years, and the technology is quite mature compared with the other alternative fuels. Key cost elements include vehicle costs (conversion or original equipment manufacturer), fuel costs, and fueling infrastructure costs.

Vehicle Purchase or Conversion Costs

Typically, the LPG vehicle population has consisted of gasoline vehicles converted or "retrofit" to run on LPG. Conversion costs are generally in the range of $1,000 to $2,000 (McCoy and Lyons, 1993a). The Clean Air Center of GasCo has provided parts and services for LPG conversions for over twenty years. Table 8-7 demonstrates the breakdown of projected LPG conversion costs (for conversions performed by GasCo, Inc.) of $2,050 for mid-sized cars, and $1,865 for trucks (State of Hawaii, Department of Business Economic Development & Tourism, 1991; Saito, 1994).

Few LPG vehicles are available from original equipment manufacturers. Ford Motor Company offers an LPG option on its F-series trucks. This option costs approximately $800 more than the equivalent gasoline model. Caterpillar is developing a gaseous fuel powered 3306 engine which can run on LPG or CNG for heavy duty applications. Cost information is not yet available for this engine.

Table 8-6
Examples of Life-Cycle Cost Analyses Results for Electric Vehicles

Vehicle Type	**Application**	**Battery Technology Type**	**Time Frame**	**EV Life-Cycle Cost** (cents/mile unless otherwise noted)	**Comparable Gasoline Vehicle Cost**	**Notes**
Passenger Van	Private Individual	generic	1995	61.7	37.5 -38.2	1,2,3,4,5
Passenger Van	Small Private Fleet	generic	1995	61.7	37.5 - 38.2	1,2,3,4,5
Passenger Van	Large Private Fleet	generic	1995	61.7	37.5 - 38.2	1,2,3,4,5
Passenger Van	Government Fleet	generic	1995	61.7	37.5 - 38.2	1,2,3,4,5
Full-Size Van	Small Private Fleet	generic	1995	61.7	44.9 - 45.7	1,2,3,4,5
Full-Size Van	Large Private Fleet	generic	1995	61.7	44.9 - 45.7	1,2,3,4,5
Full-Size Van	Government Fleet	generic	1995	61.7	44.9 - 45.7	1,2,3,4,5
Source: CEC, 1991						
Passenger Car	None noted	Hybrid: lead-acid battery + 30 hp engine	near term	20.6	not given	5,6,7
Source: Marr and Walsh, 1986						
DSEP Van	None noted	lead-acid	near term	64 or 42	not given	8,9
Source: Marr and Walsh, 1987						
IDSEP Van	None noted	range of technologies	1995	15 to 30	not given	10,11,12,13
G-Van	None noted		1995	30 to 37	not given	11,12,13
Source: Marr et al, 1989						
Shuttle Bus (22')	Commercial	lead-acid	1993	$2.53/mi	$2.19/mi	1,14,15
Shuttle Bus (22')	Commercial	lead-acid	1993	$4.18/passenger	$3.37/passenger	1,14,15,16
Source: AEC analysis based on SVMC cost data, personal communication, Ken Allison, 1993						
Delivery Truck	Commercial	lead-acid	1992	27 to 30	29 to 31	17, 18, 19
Source: Browning, April 1993						

Notes:

1. 10,000 annual miles assumed.
2. 1990 dollars
3. Battery replacement costs not included (analysis assumes vehicle is resold with old batteried after 5 years).
4. Batteries assumed to meet USABC Advanced Battery Technology Criteria, with 5 year life and cost of $6000.
5. Base vehicle costs (excluding sales tax, licensing fees, etc.) assumed to be $26,899 for the passenger van and $24,986 for the full-size van, including batteries.
6. Battery life of 6.4 years and cost of $711 assumed.
7. Vehicle cost of $9867 assumed.
8. State-of-the-art lead-acid batteries assumed. Off-the-shelf configuration gave 64 cents/mi, same batteries with design parameters modified to give minimum life-cycle cost resulted in 42 cents/mi cost.
9. DSEP is Dual-Shaft Electric Propulsion van being developed by Eaton under DOE funding.
10. IDSEP is the Improved Dual-Shaft Electric Propulsion van
11. Annual driving distance assumed to be equal to range of vehicle on a single charge: maximum range per charge varied with battery type (i.e. each technology associated with a different cost and range).
12. Battery technologies analyzed include ZN/Br2, LiA1/FeS, Na/S (max range), Ni/Fe, Fe/Air, and Tubular (min range). Highest costs were with Tubular, lowest with Na/S and Fe/Air.
13. Vehicle capital cost assumptions not noted. Prototype G-Vans were sold for about $55,000 to $60,000.
14. Costing includes vehicle costs, fuel costs and battery costs.
15. Life of electric shuttle assumed 50% longer than gasoline shuttle 10 year life based on DOE estimates.
16. SVMC calculates that the EV shuttles in operation attract more passengers than the gasoline shuttles, at a ratio of about 1.4:1. This results in lower per passenger cots
17. Gasoline truck gross vehicle weight assumed to be 10,500 pounds.
18. Gasoline truck price of $35,000 and EV price of $43,000 assumed.
19. Assumed electricity cost of 8 cent per kWh. Assumed gasoline cost of $1.36 per gallon (California Phase II).

General Notes: A. None of the above results take EPACT incentives into account.

Table 8-7
Conversion Costs for LPG Vehicles

Item	Parts Cost ($)	Labor (Hrs)
Parts (kit)	748.00	16 hours (car or van)
Tank	500.00	12 hours (truck)
Remote fill (not required for some vehicles)	150.00	
Fuel control processor	288.00	

Propane and Infrastructure Cost

GasCo provides propane for motor vehicle use at a separate rate schedule than propane for other uses such as heating and cooking. For vehicle use, propane is essentially priced to be competitive with gasoline after all appropriate motor fuel taxes have been applied. For example, in 1993, on Oahu, fleets paid from $1.00 to $1.33 per gallon depending on their annual consumption volume[16] (Saito, 1994). This translates to a price of $1.36 to $1.82 per gasoline equivalent gallon. Fueling infrastructure is supplied by GasCo (Saito, 1994). Currently, there are about 45 LPG refueling sites supplied by GasCo throughout the islands as well as a few sites supplied by Oahu Gas Service and Aloha LP Gas (Kepoo, 1994). Availability of competitively-priced LPG in Hawaii (for fleet use) reduces the incremental cost of LPG vehicles over conventionally fueled vehicles to the costs associated with vehicle procurement or conversion.

Retail propane, primarily sold for use in barbecue grills and for industrial uses, has a retail price (without highway taxes) of about $2.00 per gallon (telephone survey, 1994), which translates into a cost of $3.36 per gasoline equivalent gallon if all taxes are applied.

Fuel Taxes on Propane

Unlike other alternative fuels, propane is taxed at a rate which is roughly proportional to its energy content ("two-thirds the rate for diesel, rounded to the nearest cent"[17]).

8.6 EXAMPLE OF A COST PER MILE COMPARATIVE ANALYSIS

Table 8-8 shows example assessments of cost per mile for a gasoline, alcohol, electric, and propane-powered passenger car. The gasoline analysis was based on the Intellichoice cost

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[16] The price of $1.00 per gallon assumes at least 400,000 gallons per year used; the price of $1.33 per gallon applies down to 800 gallons used per year (Saito, 1994).

[17] Hawaii Revised Statutes, Section 243.

information for a 1994 Ford Taurus GL (Intellichoice, 1994). Figure 8-10 shows the assessment results graphically.

Two alcohol cases were examined: a low fuel cost case and a high fuel cost case, as shown in Table 8-8. Except for EVs, fuel costs, in these analysis, are fuel costs at the pump and therefore include the cost of related fueling infrastructure. EV infrastructure was instead included as a capital item (estimated on a per vehicle basis) rather than as a component of fuel price. Alcohol and propane fuel prices are given per gasoline equivalent gallon (GEG). Propane prices are based on prices for fleet vehicles using a central fueling location.

It is important to note that this analysis is merely a set of examples (other assumptions could give substantially different results) and cannot support general conclusions about the relative cost-competitiveness of these technologies. However, this analysis can illustrate a few interesting points. First, EVs, under these assumptions, are more costly on a per-mile basis than either gasoline, propane, or alcohol vehicles operating on reasonably competitively priced fuel; however, EVoperating costs are much lower than gasoline, alcohol, or propane vehicle operating costs (and would be even if the EV infrastructure cost were loaded onto the fuel price). Therefore, if EV vehicle and battery costs could be reduced, EVs could become very competitive in the marketplace.[18]

Table 8-8
Example Cost Per Mile Calculations: Gasoline, Alcohol, Electric and Propane Automobiles

Common Parameters (Assumptions)		
Miles per Year	10,000	
Discount Rate	10%	
Years of ownership	5	
Resale value	45%	of initial cost

Notes 1) Assume insurance, fees, and vehicle-related taxes are the same regardless of fuel/energy type; these costs are not included in the comparison.
2) Resale value after 5 years based on Intellichoice* fifth year resale value for a 1994 model year Ford Taurus GL.

Fuel Costs (taxes included)		
Gasoline	$1.52	per gallon
M85 or E85, Low Fuel Cost	$1.43	per GEG*
M85 or E85, High Fuel Cost	$3.81	per GEG
Electricity	$0.105763	per kWh
LPG	$1.96	per GEG

* GEG, 'gasoline equivalent gallon,' refers to the volume of any fuel which contains the same amount of energy as a gallon of gasoline

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[18] The issue of vehicle range is not addressed in this cost comparison. The implicit assumption is that the user's needs are met by the range of whichever technology vehicle is purchased and that no additional cost are incurred as a result of reduced range compared with a gasoline vehicle.

Table 8-8 (continued)
Example Cost Per Mile Calculations: Gasoline, Alcohol, Electric and Propane Automobiles

Gasoline	
Cost Category	Cost (1994$)
Vehicle cost	$16,380
Resale value	$7,371
Annualized cost	$3,003
Vehicle cost per mile	$0.30
Average fuel economy	21.8 mpg
Fuel cost per year	$699
Maintenance per year	$1,044
Repair per year	$130
Annual operating cost	$1,873
Operating cost per mile	$0.19
Total Cost per Mile	**$0.49**

Alcohol (M85 or E85)		
Cost Category	Low Fuel Cost $1.43 per GEG	High Fuel Cost $3.81 per GEG
Vehicle cost	$16,380	$16,380
Resale value	$7,371	$7,371
Annualized cost	$3,003	$3,003
Vehicle cost per mile	$0.30	$0.30
Average fuel economy (miles per GEG)	21.80	21.80
Fuel cost/year	$656	$1,747
Maintenance per year	$1,068	$1,068
Repair per year	$130	$130
Annual operating cost	$1,854	$2,945
Operating cost per mile	$0.19	$0.29
Total Cost per Mile	**$0.49**	**$0.59**

Table 8-8 (continued)
Example Cost Per Mile Calculations: Gasoline, Alcohol, Electric and Propane Automobiles

Electric	
Cost Category	Cost (1994$)
Vehicle cost	$21,380
Vehicle cost w/EPACT tax credit	$19,242
Resale value	$9,621
Annualized cost of vehicle	$3,207
Infrastructure cost per EV	$1,000
Annualized infrastructure	$65
Battery replacement cost	$2,000
Annualized battery cost	$1,333
Total annualized costs	$4,605
Vehicle cost per mile	$0.46
Average fuel economy (kWh per mile)	0.30
Fuel cost/year	$317
Maintenance per year	$522
Repair per year	$130
Annual operating cost	$969
Operating cost per mile	$0.10
Total Cost per Mile	**$0.56**

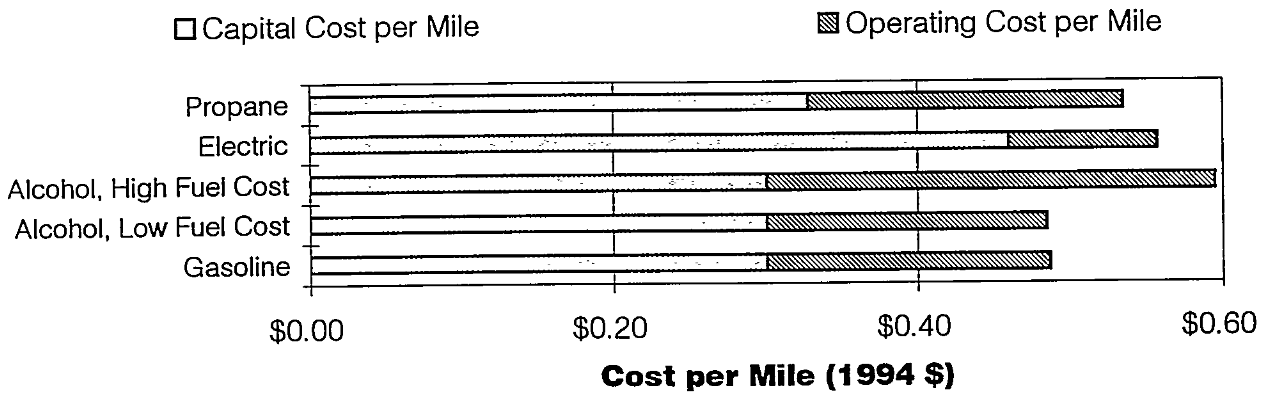
Propane	
Cost Category	Cost (1994$)
Vehicle cost	$17,880
Resale value	$8,046
Annualized cost of vehicle	$3,278
Vehicle cost per mile	$0.33
Average fuel economy (miles per GEG)	21.80
Fuel cost/year	$900
Maintenance per year	$1,044
Repair per year	$130
Annual operating cost	$2,074
Operating cost per mile	$0.21
Total Cost per Mile	**$0.54**

Alternative Fuel Vehicle Assumptions:

1) Alcohol vehicle price is the same as for the comparison gasoline vehicle.
2) The EV price, including batteries, is $5,000 more than that of the comparison gasoline vehicle.
3) The propane vehicle price is $1,500 more than that of the comparison gasoline vehicle.
4) EV capital cost includes annualized costs for infrastructure installation ($1000, 30 year life) and replacement of lead acid batteries ($2,000, every 20,000 miles).
5) Alcohol and propane vehicle energy efficiencies are equivalent to the comparison gasoline vehicle.
6) EV energy efficiency is 0.3 kWh per mile.
7) Alcohol FFV maintenance costs are higher than gasoline costs due to the use of more costly oil ($1.50 per quart incremental cost).

8) EV maintenance costs are one half the cost of maintaining a conventional vehicle (California Air Resources Board, April, 1994).
9) Propane vehicle maintenance costs are equal to the cost of maintaining a conventional vehicle.
10) Alcohol, electric, and propane vehicle repair costs are equal to conventional vehicle cost (based on prices of nationally available 5-year service contracts).

Figure 8-10
Capital and Operating Costs per Mile



8.7 CONCLUSIONS

The most obvious conclusion of the cost analyses presented here is that, with current technology, prices, and taxes, alternative fuels (other than low-level ethanol blends) are more costly than gasoline. The analyses provide much more information than that, however. Each cost projection is based on several parts. It is possible, with this analysis and the analysis tools developed in this project, to estimate what will happen if any one of those parts - or several of those parts - were to change.

The most significant cost element in alcohol-fueled transportation is the cost of the fuel. Projected fuel costs for M85 and E85 are higher than gasoline, on a gasoline equivalent gallon basis, for all cases tested. If state and county fuel tax rates were to be adjusted on the basis of energy content, projected M85 and E85 costs would be comparable or less than current gasoline prices in two cases. Key cost elements are feedstock and processing costs; application of federal tax incentives; and fuel transport (shipping, hauling, and terminal) costs.

For electric vehicles, the most significant cost element is the cost of the vehicles. A variety of technologies, manufacturers, and prices are available; the rapid pace of development in this area makes a comparative cost estimation for electric vehicles extremely difficult. If electric vehicle purchase costs could be reduced, EVs could become very cost-competitive in the marketplace.

For fleet use of propane, the main cost element is the vehicle conversion cost. For non-fleet use of propane, the high price of retail propane is an additional factor.

The next chapter explores some possible means, given the costs projected in this chapter, of encouraging the use of alternative transportation fuels.

CHAPTER 9

POTENTIAL MEASURES TO ENCOURAGE ALTERNATIVE TRANSPORTATION FUELS AND VEHICLES

9.1 INTRODUCTION

In contrast to the marine and aviation sectors, where there is minimal potential for state involvement with respect to energy use, the ground sector is both large enough to be significant[1] and amenable to influence by the state. Therefore, since governmental involvement may assist in achieving energy goals, it is informative to present possible governmental actions to develop alternative fuel use in the state's ground transportation sector. The presentation is structured by degree of government involvement. This Chapter is limited to a description of the possible range of measures. A suggested program is deferred to Chapter 11.

9.2 DISTINGUISHING MEASURES BY DEGREE OF GOVERNMENT INVOLVEMENT

As shown in Table 9-1, Government involvement can range from large (the government provides fuels) to relatively small (e.g. weak incentives). With any approach, the government can also sponsor and lead research, development, and demonstration (RDD) programs.

Tables 9-2 and 9-3 show possible government actions organized by their aims. Measures focusing on alternative fuel supply and infrastructure development are shown in Table 9-2. Measures focusing on alternative fuel vehicles (AFVs) are shown in Table 9-3. These tables contain governmental measures that might be taken. Some measures are further characterized by an "S" (a measure primarily affecting the supply of alternative fuels or AFVs) or a "D" (a measure primarily affecting the demand for alternative fuels or AFVs).

9.2.1 GOVERNMENT-PROVIDED FUEL

Government-provided fuel entails the highest degree of government involvement with the following governmental roles:

- fuel selection;
- investment;

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[1] See Chapter 2.

Table 9-1

Lead Roles in Different Implementation Approaches

In this implementation approach...	who has the lead or chief role in...			
	Setting Research, Development, and Demonstration Agenda	**Choosing Favored Fuels**	**Pricing and Marketing Fuels**	**Investing in Fuel Production Facilities**
Government provided fuel	Government	Government	Government	Government
Financial incentives	Government	Government	Government	Industry
Mandates/requirements/standards	Government	Government or Industry	Industry	Industry

Table 9-2

Possible Measures to Promote Alternative-Fuels Use and Fuel Infrastructure Development

RDD	Requirements/Standards	Incentives	Government Investment
• Government RDD on alternative-fuel technologies	• Gasoline and diesel fuel nonpetroleum or oxygenate content standards (S)* • Fuel pool averaging based on fuel type or petroleum content (S)[1] • Fuel pool averaging based on fuel cleanliness (S)[3,6] • Fuel availability/distribution requirement (S) • Domestic content requirement (S) • Electric vehicle charging system requirements (S) • Tank methanol/ethanol compatibility rule (S) • Use-permit or business license requirements (S)[4] • Fleet fuels use requirements (D) • % of sales = zero emission vehicles (ZEVs) (D) (effectively electric vehicle sales requirement)	• Investment tax credit (S) • Tax deductions for investment (S) • Loan guarantees/bond support/loans (S) • Fuel fees or taxes (D) • Ratepayer support for utility-supplied fuels (S) • Direct $ support for favored fuels or production/ distribution infrastructure (S)[2] • High-occupancy vehicle (HOV) facility/parking access if using favored fuels (D) • Fuel-cycle CO_2 fees (D)[5] • Emissions-related fees (D)[6] • Emissions reduction credits (D)[6] • Credits for alternative fuel use in a ridership or congestion management program	• Government investment or co-investment (S) in fuel production/distribution facilities

Notes:

* "S" denotes a measure that aims mainly to encourage the supply or availability of alternative fuels. "D" denotes a measure that aims mainly to encourage the demand for alternative fuels.

1) Fuel pool averaging denotes a flexible averaged regulation establishing overall standards for nonpetroleum energy use in all transportation fuels sold.
2) Includes alternative fuel tax credits, alternative fuel blending credits, exemption for excise taxes, sales taxes, and/or property taxes, grants, and other forms of direct support or subsidy.
3) As an example, fuel pool averaging would allow credits against a gasoline benzene standard for non-gasoline transportation fuels sold.
4) Refers to conditions requiring alternative fuel availability in a land-use permit (as for gasoline stations) or a business license.
5) Would favor most biomass-derived fuels.
6) Emissions-related incentives tend to favor clean nonpetroleum fuels.

Table 9-3

Possible Measures to Promote Alternative-Fuel Vehicles (AFVs)

RDD	Requirements/Standards	Incentives	Government Investment
• Government RDD on AFV technologies	• Vehicle efficiency standards (S)[*3,8] • Vehicle fuel economy minimum, with credits for AFVs (S)[8] • Vehicle CO_2 emissions standards (S)[7] • Vehicle weight limits[8] • Low emissions standards with reactivity adjustments (S)[5] • % of sales = AFVs (S) • Fleet rules for AFVs (D) • Government fleet AFV purchase requirements (D) • AFV requirements for government lease vehicles (D) (especially for vehicle rentals and transportation services) • AFV requirements for government bidders (D) • Vehicle purchase fuel economy minimums or standards or weight/horsepower limits for fleets (D) with credits for AFVs[8] • % of sales = ZEVs (S)[9] • Fleet rules requiring low-emission vehicles (LEVs) (D)[10]	• Vehicle efficiency standards or fuel economy minimums with incentives for AFVs (S)[1,3,8] • Investment tax credits or deductions (S) • Tax credits or deductions for AFV vehicle cost or incremental vehicle cost (D) • Exemptions from license fees, registration fees, sales taxes, excess taxes, ad valorem taxes, use fees (D) • Direct cost support for AFVs • HOV/parking access for AFVs (D) • Scoring preferences for government bidders with AFV programs (D) • Land-use measures to enhance utility of electrical vehicles (EVs) (D) • Direct cost support for fuel-efficient vehicles (D)[4,8] • DRIVE+ "feebates" for fuel efficiency with AFV credits (D)[2,6] • Gas guzzler taxes with credits for AFVs (D)[8] • DRIVE+ "feebates" based on emissions performance (D)[2]	• Government investment or co-investment in alternative-fuel vehicle production facilities

Table 9-3

Possible Measures to Promote Alternative-Fuel Vehicles (AFVs) (continued)

RDD	Requirements/Standards	Incentives	Government Investment
		• Direct cost support for low-emission vehicles (D) • Ridership-rule or traffic congestion program credits for clean fuel vehicles (D)	

Notes:

* "S" denotes a measure that aims mainly to encourage the supply or availability of alternative-fuel vehicles. "D" denotes a measure that aims mainly to encourage the demand for alternative-fuel vehicles.

1) Provided in Alternative Motor Fuels Act of 1988.
2) Feebates are intended to be revenue neutral, with fee revenues equaling rebate obligations.
3) Federal law currently appears to preempt independent state action; preemption may be subject to litigation.
4) Could include rebates, grants, tax credits and deductions, exemptions from all or part of taxes such as registration/license fees, sales taxes, excise taxes, ad valorem taxes, use fees.
5) States would have to opt in to California standards or demonstration program. Low emissions standards may favor clean nonpetroleum fuel technologies.
6) State feebates for an energy efficiency or fuel economy purpose may be preempted by federal CAFE legislation.
7) Federal law probably prohibits state action.
8) Can favor AFVs if credits or incentives are provided for vehicles using nonpetroleum fuels.
9) ZEV = "zero emissions vehicle," presumably as defined in California emissions standards.
10) LEV = "low emissions vehicle," referring to vehicles meeting lower emissions standards than some baseline standards, perhaps as defined in California emissions regulations or in "clean fuel vehicles" as defined in Clean Air Act Amendments of 1990. Low emissions standards may favor clean nonpetroleum fuel technologies.

- fuel production and distribution; and
- pricing.

This approach may be appropriate to an energy emergency (see Hawaii Energy Strategy Project 6, Energy Vulnerability Assessment and Contingency Planning) where speed and decisiveness may be more important than "optimum" energy choices. This approach has been used in wartime economies and in South Africa to promote energy independence during international economic sanctions. It was fundamentally the approach followed by Brazil in the 1980s to increase ethanol use in vehicles, the most rapid deep substitution of petroleum fuels ever achieved in an industrialized society. About half of the gasoline use was displaced by ethanol in approximately 10 years. More moderate forms of this approach might be considered where local economic interests in alternative fuels are very significant, such as in Hawaii.

Although direct government investment for transportation infrastructure is common (highways, transit, ports), the use of government investment has not been common in the U.S. to influence transportation energy use.[2] Nonetheless, government investment in alternative fuel production or AFV manufacturing facilities may be appropriate when the local economy would benefit but private investment is hesitant because of market uncertainties.

9.2.2 INCENTIVES

Incentives can be financial or non-financial.

With financial incentives, government chooses favored fuels, offers financial incentives, attempts to steer the market, but does not become a direct investor. Nevertheless, by choosing fuels and specifying incentives, government implicitly participates in pricing and therefore intrudes into the market.

Some proposed programs are "revenue-neutral." Revenues from fees on "discouraged" vehicles or fuels fund the rebates of "encouraged" vehicles or fuels.

Incentives can range from strong to weak, and include such measures as:

- take or pay contracts which guarantee purchase volumes at defined prices;
- low-interest, no-interest, or guaranteed loans;
- direct subsidies;
- tax relief (credits, deductions, and exemptions);
- government bond issues;
- direct credits for sales of alternative fuels;
- extra taxes on gasoline and diesel fuel; and
- extra taxes for vehicles that can only use gasoline or diesel fuel.

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[2] Except perhaps in wartime.

Tables 9-2 and 9-3 list incentives that have been proposed to encourage energy diversification, increased fuel economy, and cleaner vehicles. Most of these measures have been implemented either nationally or in select localities. Hawaii has seen similar proposals, including excise tax exemptions, tax credits, exemptions from registration fees, and "feebate" (revenue neutral) approaches to encouraging fuel-efficient or alternative-fuel vehicles. Bond issues for alcohol production facilities and AFV manufacturing have also been enacted in Hawaii.

Financial incentives were the main approach used to introduce unleaded gasoline and catalyst-equipped vehicles into European countries. This approach was also used to encourage natural gas vehicle technologies in Canada and New Zealand.

Financial incentives are a key part of the Energy Policy Act (EPACT) (see Chapter 4). Table 9-4 summarizes other federal incentives available for alternative fuels. (For more information see U.S. Senate, 1992; U.S. Department of Energy, 1992.)

An important incentive is created when regulated utilities are allowed to place certain costs of providing transportation energy into the pool of expenses that are covered by all the purchasers of the energy provided by the utility. When this treatment applies to capital costs it is termed "ratebasing," the form of capital recovery used by regulated utilities. However, in some state and local programs, AFV operating costs have been recovered from all ratepayers, and not just the owners of AFVs. If implemented in Hawaii, this incentive would allow the electric utilities to "ratebase" their costs in providing an electric vehicle (EV) recharging infrastructure and other components to promote EV utilization in which the utility chose to invest.

"Ratebasing" is usually proposed as a short-term measure and is typically justified in relation to long-term public benefit and the need to explore pre-commercial emerging technologies. Long-term deployment of alternative fuel technologies by regulated monopoly utilities is generally thought to be a function of the investors, not the ratepayers. This is especially true where there are competing forms of transportation energy in the market, so that consumers are not dependent on one delivery infrastructure.

Non-financial incentives include preferential parking and lane access for high-occupancy vehicles (HOVs). Such proposals have been made in Hawaii.

9.2.3 MANDATES AND STANDARDS

Mandates entail government selection of favored fuels, but not investment and pricing decisions. Examples include:

- fuel specifications;
- fleet purchase requirements; and
- requirements on manufacturers to supply AFVs.

Table 9-4

Other Federal Incentives for Alternative Motor Fuels: Alcohol Fuel Credits (Ethanol and Methanol Produced from Biomass)

- Alcohol mixtures credit (to blender)[1]
  - 54 cents per gallon of alcohol of at least 190 proof (or 5.4 cents excise tax exemption for 10% blends, 4.16 cents for 2.2% blends, 3.08 cents for 5.7% blends)
  - 40 cents per gallon of alcohol between 150 and 190 proof
- Pure alcohol credit (to retail seller)[1]
  - Same as for mixtures credit
- Some ethanol producer credit
  - 10 cents per gallon of ethanol produced from plants of less than 30 million gallons per year, for up to 15 million gallons produced each year

Note:

1) Credits count as income and are limited to 25% of liability or 50% of minimum tax, therefore, the excise tax exception is usually preferred.

Mandates are generally viewed as less intrusive than financial incentives because most mandates establish a functional specification and let fuel providers and equipment manufacturers respond with market-driven approaches. Government avoids direct involvement in pricing.

For example, unleaded gasoline was introduced in the U.S. by a mandate that it be made available to support the catalyst-equipped automobiles that manufacturers offered in response to improved emissions standards. The Clean Air Act Amendments of 1990 mandated new reformulated gasolines with oxygenate requirements. While emissions standards appear "fuel neutral" since they do not reference specific fuels, they can be used to encourage cleaner alternative fuels if emissions standards are set low enough.

Mandates are perhaps the most aggressive feature of EPACT, which includes requirements for certain fleets to purchase a specified proportion of AFVs when new or replacement vehicles are purchased (see Chapter 4). Some state and local governments have instituted similar provisions for their fleets, such as transit buses. Such proposals have also been made in Hawaii.

Government standards (a form of mandate) effectively control gasoline and diesel fuel emissions, but leave the details to the fuel providers. These standards address sulfur and aromatic limits for diesel fuel, vapor pressure, sulfur, and oxygen requirements in gasolines.

Certain governments have established standards that explicitly promote alternative fuels and others have tried to achieve the same effect by specifying oxygen content. These standards have been actively supported by those interested in the use of alcohols in motor fuels. Ethanol has frequently been used to meet oxygen requirements in gasolines, but ethers produced from ethanol and methanol are used as well.

For energy diversification, "content" standards have been proposed and were implemented in Brazil in the early years of its ethanol program.[3] In the case of Brazil, the content requirement was for ethanol. The 1994 session of the Hawaii Legislature passed an ethanol content standard (Act 199).

Content standards are regarded as supply-side measures since they promote the availability of alternative fuels or AFVs. From the viewpoint of alcohol producers, alcohol content requirements create a new demand. In Hawaii, for example, Act 199 of the 1994 legislature is expected to create a demand for ethanol and this demand is expected to spur the supply of ethanol, with benefits for the agriculture industry.

9.2.4 RESEARCH, DEVELOPMENT AND DEMONSTRATION PROGRAMS (RDD)

The government has long played a role in basic research for the common benefit that improves fundamental understanding and helps stimulate basic breakthroughs. Since U.S. business investment often focuses on short-term payoffs, government RDD programs can be particularly appropriate when technical risks are high and development times are long. Programs can involve both government and the private sector,[4] and government research can complement private research.

RDD programs improve alternative fuel technologies and help ease their introduction by giving potential users familiarity with the technologies. Current government research on alternative transportation fuels is actually at a relatively low level. Total U.S. Department of Energy (U.S. DOE) expenditures on alternative motor fuel production and utilization currently average about $200 million annually (U.S. DOE, 1993; Gross, 1993). For comparison, expenditures for the Clean Coal Program are about $475 million, and total fossil energy research and development expenditures are about $2 billion. The total U.S. DOE budget is about $17 billion.

Alternative motor fuel programs are also supported by the Department of Defense (fiscal year 1994 commitments are about $14 million), the Environmental Protection Agency and some state energy and air quality agencies. EPACT includes provisions to expand research on

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[3] Ethanol was required to be added to gasoline to provide an early market for ethanol before dedicated ethanol cars gained significant market share.

[4] For example, the cooperative effort between the U.S. carmakers and the Clinton Administration aimed to develop the 'car of the future' focuses on improved fuel economy, reduced emissions, and alternative fuels. EPACT contains important research programs.

advanced vehicles. The Clinton Administration has also announced their Clean Car Initiative, an RDD program with an emphasis on defense conversion. Hawaii is receiving $5 million from the Defense Advanced Research Projects Agency in fiscal year 1994 to fund an electric vehicle demonstration program.

Vehicle manufacturers, the utility industry, and the fuel suppliers also conduct research and development on alternative motor fuels. No comprehensive compilations of these private expenditures are available, but it is unlikely that in the aggregate they exceed U.S. DOE expenditures for alternative fuels. Thus, although energy use in the transportation sector is substantial compared with other energy uses, RDD expenditures devoted to alternative fuels are rather small compared with expenditures aimed at increasing the overall energy supply or decreasing the environmental impacts of energy use. Nevertheless, government RDD leadership in alternative motor fuels is important, especially in the case of battery and fuel-cell electric vehicles and other advanced technologies.

9.2.5 ADJUSTMENT OF FUEL TAX RATES ON THE BASIS OF ENERGY CONTENT

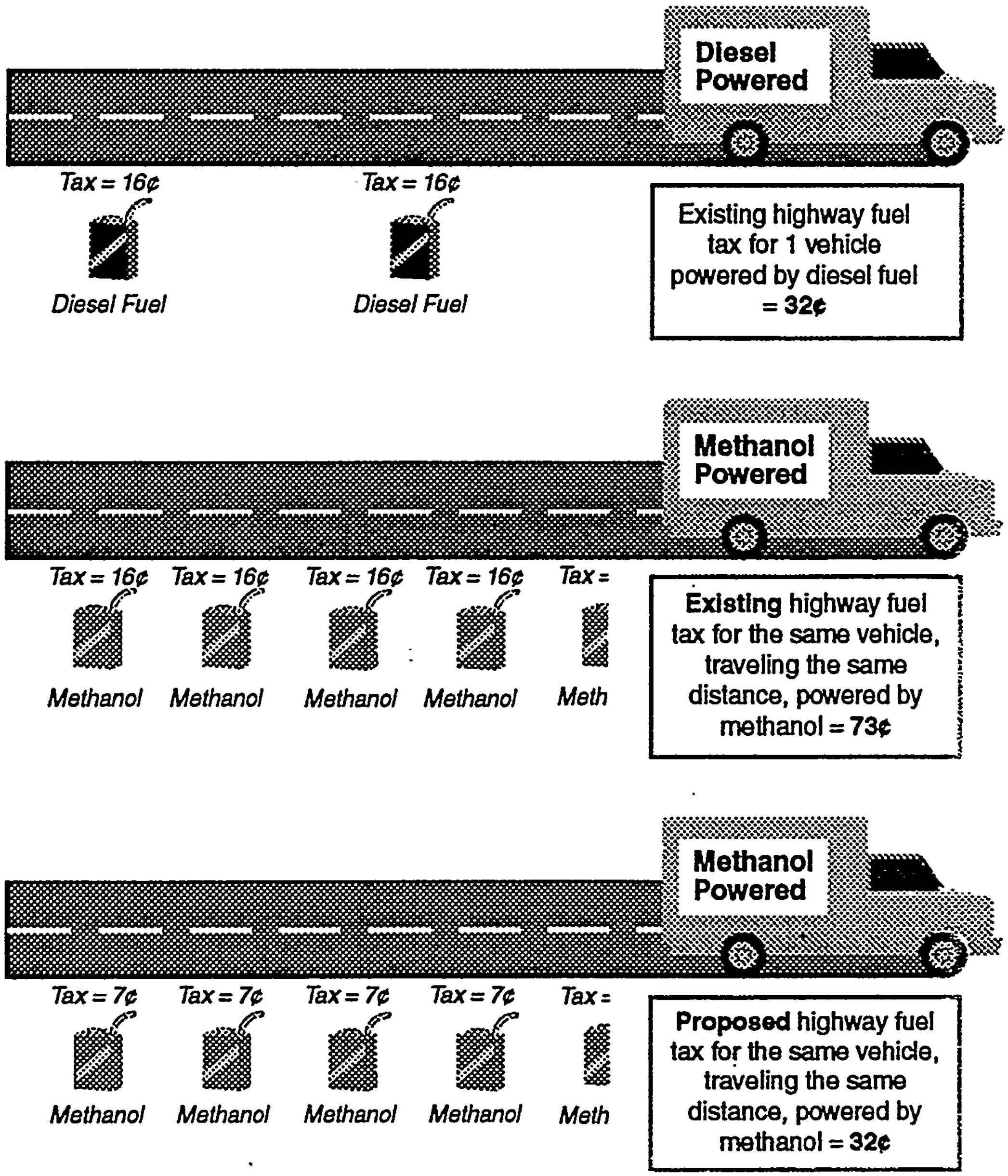
Adjusting fuel tax rates on the basis of energy content would remove a disincentive to the use of alternative fuels. This is not a tax incentive. Taxing alternative fuels based on the energy content of those fuels would have no effect on the total amount of revenue received by the highway fund.

Motor fuels are taxed on a per-gallon basis. This puts most alternative fuels at a disadvantage on a cost-per-mile basis, since alternative fuel vehicles use more gallons to travel the same distance (see Figure 1). As the fuel tax laws are currently written, alternative fuels are taxed at the same per-gallon rate as diesel in spite of the difference in their energy content. This results in the operator of a methanol-powered vehicle (center illustration, Figure 9-1) paying more than twice as much in fuel taxes than as for a diesel-powered vehicle (top illustration, Figure 9-1).

However, if fuel taxes for alternative fuels were based on energy content, the amount of fuel tax paid by the operator of an alternative fueled vehicle (bottom illustration, Figure 9-1) would be the same as for a conventionally-fueled vehicle (top illustration, Figure 9-1).

An adjustment to fuel tax rates, even prior to the alternative fuels being available, is important for several reasons. First, costs are a significant consideration for a fleet considering the use of alternative fuels. The current system of taxing fuels on the basis of volume (rather than energy content) results in a significant additional cost item. The barrier is sizable; for a fleet of ten heavy-duty vehicles traveling 10,000 miles per vehicle per year, the additional highway taxes imposed due to fuel choice could be thousands of dollars (see Figure 9-2).

Figure 9-1
Alternative Fuels Have Less Energy Per Gallon;
Therefore, More Gallons are Used to Travel the Same Distance

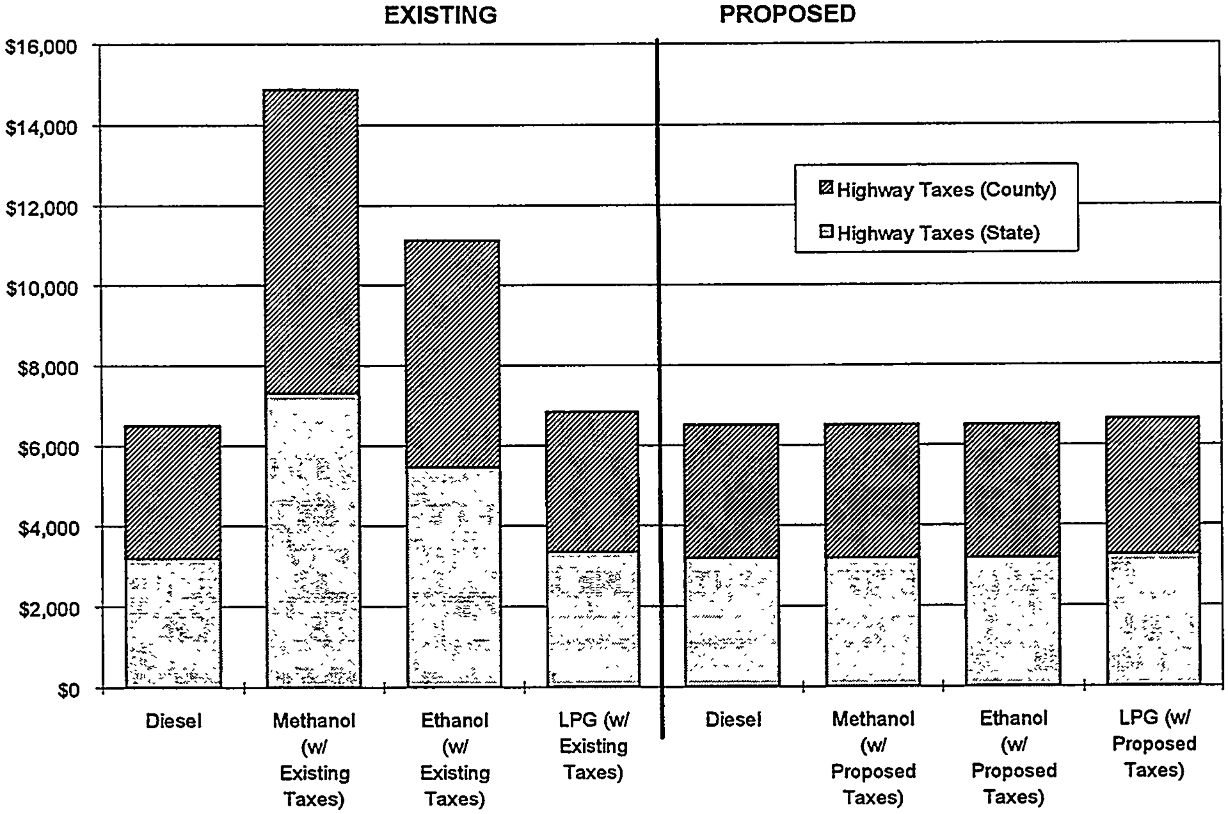


Existing highway fuel tax for 1 vehicle powered by diesel fuel = **32¢**

Existing highway fuel tax for the same vehicle, traveling the same distance, powered by methanol = **73¢**

Proposed highway fuel tax for the same vehicle, traveling the same distance, powered by methanol = **32¢**

Figure 9-2
Annual State and County Highway Taxes
Assuming a Fleet of 10 Heavy Duty Vehicles Traveling 10,000 Miles Per Year



Taxes which are assessed on a per-gallon basis ("existing" rates, above) result in uneven annual charges for different fuels. As shown in the graph, the "proposed" rates would result in the same revenue for the same vehicle-miles traveled, regardless of fuel type.

Second, even if fuel production, transport, and vehicle costs for alternative fuels (see Chapter 8) are brought down to be on a par with conventional fuels, as long as the tax rates are higher for the alternative fuels, they will not be price-competitive. Therefore, before even considering incentives or other measures for alternative fuels, the issue of fuel taxes should be addressed. This measure is completely fuel-neutral, requires no revenue, and there is even a precedent for such an adjustment.

An adjustment to fuel tax rates has already been implemented in the case of liquefied petroleum gas (LPG); the current tax rate is "two-thirds the rate for diesel, rounded to the nearest cent." As shown in Figure 9-2, this rate results in the existing taxes on propane being roughly on a par with diesel.

A similar adjustment could be extended to the other alternative fuels as well by replacing the phrase "liquefied petroleum gas" with the term "alternative fuels" and specifying the following rates:

Table 9-5
Proposed Adjustment to State and County Highway Tax Rates

Fuel	Approximate factor (nearest fraction)	Proposed factor (decimal)
Methanol	3/7	0.437
Ethanol	3/5	0.585
LPG	2/3	0.649

9.3 CONCLUSION

There is a wide range of possible measures which could move Hawaii towards a greater use of alternative fuels for transportation. Some, such as government-provided fuel, involve extensive government involvement. Others, such as research, development and demonstration programs, are investment for long-term societal goals such as energy security, economic development, or environmental preservation. And still others, such as adjustment of fuel taxes to reflect the lower energy content of alternative fuels, simply reduce existing barriers without promoting any particular fuel or set of fuels.

The next chapter explores potential benefits of alternative fuels and estimates the costs and effectiveness of the various possible alternative fuel measures.

CHAPTER 10

IMPACT AND EFFECTIVENESS OF POTENTIAL ALTERNATIVE FUEL MEASURES

10.1 DESIGNING AN ALTERNATIVE TRANSPORTATION FUEL PROGRAM

Chapters 2 and 3 described future energy needs in the state's transportation sector. Even with conservation efforts, transportation energy demand is projected to increase, but as described in Chapter 4, a portion of this demand could be satisfied with alternative fuels. Increased utilization of alternative fuels would further the state's energy goals, such as energy security and benefits to the local economy, while continued reliance on petroleum in the transportation sector would not promote these goals. Chapter 7 described how sufficient resources were available locally to produce a substantial portion of the state's ground sector transportation energy demand, but Chapter 8 showed that locally produced transportation energy would still be substantially more expensive at the pump than fuels derived from imported petroleum.

This Chapter introduces and evaluates measures culled from the possibilities described in Chapter 9 that the state could follow to actively manage energy use in its ground transportation sector.

An evaluation of the benefits of alternative transportation fuels begins with an evaluation of the ability of the alternative fuels to contribute to long-term objectives.

Then, potential measures to increase the use of alternative fuels may be evaluated in terms of facilitating the eventual accomplishment of the long-term objectives. Transition to widespread use of alternative fuels is a gradual process, primarily due to the time necessary to introduce Alternative Fuel Vehicles (AFVs) into the vehicle population.[1] A 20-year horizon appears necessary for petroleum substitution of 20 - 30 percent (see Chapter 4). Therefore, near-term alternative fuel actions are the first steps along a road which will eventually lead to (or not lead to) the accomplishment of long-term objectives.

An alternative transportation fuels program should maximize benefits while minimizing incremental costs. However, benefits and costs are difficult to quantify and have many uncertainties. For example, although in general benefits and costs of oil substitution depend strongly on the degree of substitution, with more substitution bringing more benefits and reduced costs through economies of scale, in some cases the easiest and most cost-effective approaches are found at smaller scales (such as utilizing limited amounts of low-cost feedstocks, or in certain limited niche markets).

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[1] 20 years would allow most of the vehicles to be turned over to AFVs. The most attractive and cost-effective vehicles that can use alternative fuels are those supplied as new vehicles by major manufacturers. However, the roll-in of new vehicles is too slow to allow large substitution to be achieved quickly even if vehicle manufacturers made most of the models alcohol-capable. Even the aggressive scenarios in Chapter 4 achieve only about 20 percent substitution by 2014. Such scenarios are unlikely to happen across the country. Rapid substitution would require a national commitment along the lines of the Brazil program, the most rapid substitution strategy ever undertaken. Although Brazil accomplished about 50 percent substitution in a decade, Brazil strongly directed the types of cars to be built (since car production was largely domestic) and also supported an aggressive vehicle retrofit program. There is no U.S. consensus that such a rapid substitution is needed. It would probably also be unwise, given the expected improvements in alternative fuels technologies.

Further complications include the following:

1. Costs of alternative fuels change with time.

Costs are expected to fall as alternative fuel production technology improves.

2. Future prices of oil cannot be accurately projected.

Future petroleum prices are uncertain, involving both short-term volatilities and long-term price changes. Scenario-based projections of petroleum prices show wide variations between low and high cases. This makes assessments of the net value of substitution programs difficult. Note also that projections are for the market price of oil and do not account for possible additional externality[2] costs which may be included in the future.

3. Net cost/benefit assessments must cover many years.

Relative costs of petroleum and alternative fuels will change with the amount of displacement and time. Many of the costs of a substitution program come early when volumes of alternative fuel and numbers of AFVs are low, and economies of scale have not yet been achieved. On the other hand, the benefits of avoiding the externalities of oil only occur after a substantial amount of petroleum substitution has been attained. Hence, costs and benefits have to be compared over many years, or in some "discounted" or "net present amount" sense.

4. Because low-cost AFVs are key to the cost-effectiveness of substitution, and Hawaii is neither a major manufacturer[3] nor consumer of vehicles, Hawaii's optimal fuel mix may be determined by decisions made outside of Hawaii.

Since Hawaii is a small market compared with the output of major vehicle manufacturers, and since costs are reduced and consumer appeal increased with factory produced AFVs (as compared to retrofits and conversions), Hawaii's "optimal" mix may be affected by decisions outside of Hawaii as large vehicle manufacturers cope with mainland Energy Policy Act (EPACT) goals and air quality programs.

5. While a substitution program must make reasonable first guesses of goals and policies, it must also be flexible.

Because uncertainties are great and least-cost approaches are difficult to define with certainty, the optimal mix (based on present information) should incorporate as much flexibility as possible. Dual-fuel, bi-fuel, and fuel-flexible vehicles[4] are more flexible than vehicles dedicated to one fuel, and fuels with uses other than transportation are better than those limited to transportation.

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[2] "Externality costs" are those costs which are attributable to the use of a product but which are paid for in such a way that the "cost" is not included in the price of the product. Examples are the costs of pollution and the costs of defending oil supplies.

[3] Although Hawaii is beginning to produce EVs and has produced converted propane vehicles, it cannot be considered a major supplier of AFVs.

[4] Dual-fuel vehicles are those which run on a combination of alternative and conventional fuels at the same time; bi-fuel vehicles are those which can run on either an alternative or conventional fuel, using only one fuel at a time; and flexible-fuel vehicles (FFVs) are those which run on variable blends of alcohol and gasoline.

Because of the factors above, it is difficult to quantify the desired amount of substitution and the "optimal" mix of alternative fuels. The important issues are the following, and they lend themselves to a semi-quantitative analysis:

1. Should Hawaii be promoting energy diversification in the transportation sector now? Is immediate substitution worthwhile?
2. Can near-term substitution objectives be related to long-term objectives? (As an example, if electric vehicle technologies are projected to improve greatly over the next 20 years, how hard should a near-term alcohol program, which could be implemented right away, be pushed?)
3. What is the long-term energy substitution objective for Hawaii's transportation sector? How should this objective be determined if costs and benefits are uncertain? In addition to the state's energy policy goals (see Chapter 5), how important should local economic benefits be in setting the substitution goal?
4. How do the long- and near-term substitution objectives relate to the screening criteria (Chapter 5)? The screening criteria compare the alternative fuels among themselves, but how do the alternatives compare to petroleum fuels?
5. Do some substitution levels have adverse impacts on local refineries, such as unbalancing their product slate? To what extent should substitution goals be affected by refinery impacts?
6. For any given displacement objective and time frame, should specific alternative fuels gain market share, and what are the optimum proportions of alternative fuels if several are worth having?
7. What are the uncertainties and contingencies, and how much program flexibility is appropriate?

The following sections address these questions.

10.2 CONTRIBUTION OF ALTERNATIVE TRANSPORTATION FUELS TO LONG-TERM OBJECTIVES

10.2.1 ENERGY SECURITY ISSUES

"Energy security" has several components (State of Hawaii, Department of Business, Economic Development & Tourism, 1993):

- "supply security" (physical availability of fuel);
- "price security" (stability of price); and
- "economic security" (protection from the consequences of energy price fluctuations elsewhere, which could involve access to non-petroleum energy supplies).

The use of alternative fuels can address all of these components of energy security, but little energy security benefit can be realized unless the petroleum substitution is large enough for the economy to function in the event of a disruption.[5] Whether this means that Hawaii should substitute 30, 50 or 70 percent of the petroleum used in its ground transportation sector is difficult to say, but to consider energy security to be achieved, the amount of substitution should be much larger than a few percent.

Note however that substitution is not desirable unless it provides benefits greater than the incremental costs of continuing to depend on oil. At today's petroleum costs, it is debated whether any substitution is worthwhile based on externality costs alone (California Energy Commission, 1994). Some analysts have concluded that oil provides more benefits at less cost than the alternative fuels, even when oil externalities and the economic benefits of local production of alternative fuels and AFVs are included; however, each region's costs and benefits are different and assessments must be made on a case-by-case basis.

The situation may be considerably different in the future. As oil reserves dwindle, substitutes for petroleum will become necessary. As that time approaches, the consideration of externalities associated with continued gasoline and diesel use becomes more important. For example, while gasoline and diesel could be produced from coal, the environmental effects of using coal as a gasoline and diesel feedstock on the scale required to replace petroleum reserves would be tremendous. At the same time, the costs of alternative fuels are expected to decrease in the future, especially if near- and mid-term programs encourage development of alternative fuel technologies.

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[5] Small amounts of substitution may have benefits that, though small, are desirable. For example, users of alternative fuels, even if small in number, are relatively insulated; conversion of wastes to a valuable resource is helpful; and it would be worthwhile to stimulate the local manufacture of AFVs.

Therefore, the long-term substitution goal may remain broad and generally correspond to the most aggressive scenarios of Chapter 4, i.e., 20-30 percent substitution by 2014. Since it would not be possible in any case to obtain large substitution very rapidly, adjustments in long-term goals would have little influence on near-term decisions and programs as long as long-term objectives are relatively large and distant. In other words, long-term goals could be regularly reevaluated and refined without affecting the near and mid-term program, as long as near-term alternative fuel actions lead in the general direction of long-term objectives.

All of these factors were considered extensively during the development of U.S. energy policy. The debates became particularly intense during the discussions of EPACT. In the end, although nominal goals of 10 and 30 percent nationwide substitution were established for 2000 and 2010, respectively, EPACT's implementation measures (fleet purchase requirements) only provide a nationwide substitution of 4 percent by 2010. The gap between the nominal goals and the substitution achieved by fleet requirements is supposed to be made up by voluntary measures, many of them at the state and local level, and the Secretary of Energy is to report to Congress periodically on the progress of the substitution effort. Many feel that the modest extent of the mandatory measures included in EPACT is deliberate, intended to provide time for alternative fuel technologies to develop and costs to be reduced. Hawaii could similarly follow the EPACT approach and distinguish long-term goals from short-term programs.

10.2.2 ENVIRONMENTAL ISSUES

Alternative fuels have several characteristics which make them environmentally attractive. First, they are generally cleaner burning, and thus contribute less to smog formation in urban areas. Second, fuels made from renewable sources (such as trees, grasses, and even waste products) add less net carbon dioxide to the atmosphere and therefore contribute less to global warming. And third, accidental leaks or spills of alternative fuels are potentially less damaging to marine environments than petroleum or petroleum product spills.

10.2.2.1 AIR QUALITY

In areas of the U.S. with air quality problems attributable to mobile source emissions, "clean fuels" and "clean vehicles" are important elements in air quality improvement programs. In 1990, sixty-one percent of carbon monoxide (CO), thirty percent of nitrogen oxides (NOx), and twenty-four percent of volatile organic compounds air pollutants in the U.S. came from burning gasoline and diesel fuels in cars and trucks (U.S. Environmental Protection Agency (USEPA), 1992).

Carbon Monoxide

Exposure to carbon monoxide, a colorless and odorless gas, can cause headaches and place additional stress on persons with heart disease (Gordon, 1991). In higher doses, it binds to red blood cells and can cause carbon monoxide poisoning or asphyxiation.

"Based on monitoring data from the State Department of Health, present air quality...is relatively good, although air quality modeling results indicate the presence of some carbon monoxide "hot spots" near traffic congested intersections" (R.M. Towill, 1991).

Ozone

Ozone, while beneficial to the Earth in the upper atmosphere, is called "smog" at ground level and can cause shortness of breath and lung damage. It is formed by the reaction of NOx and hydrocarbons in the presence of sunlight.

"EPA's own clinical laboratories found that otherwise healthy, exercising individuals show significant effects after six hours of breathing ozone at levels below the threshold of the current health standard...the long-term effect of repeated exposures to such levels is one of the many questions remaining in the area of health-effects research" (Garrison, 1991).

Emissions from Alternative Fuels

Figure 10-1 shows data from the CleanFleet program.[6] Although several manufacturers' vehicles were involved in the CleanFleet program, only one manufacturer had vehicles operating on all four fuels (compressed natural gas (CNG), a blend of 85% methanol and 15% gasoline (M85), liquefied petroleum gas (LPG/propane), and gasoline); that data is shown below.

All of the alternative fuel vehicles produced less carbon monoxide than the control gasoline vehicles. Although some alternative fuels produced more NOx and hydrocarbons than gasoline, it is the reaction between NOx and hydrocarbons (some hydrocarbons are less reactive than others) that produces ozone. The alternative fueled vehicles produced fewer ozone-causing emissions overall than the control gasoline vehicles.

Tailpipe emissions from electric vehicles are zero, since no combustion is occurring on-board the vehicles. When emissions from power plants are considered, carbon monoxide emissions are close to zero and emissions of NOx, which depend on the particular power plants producing electricity at the time the electric vehicles are charged, are also much less than for gasoline vehicles. With Hawaii's statewide average mix of power production, CO and NOx emissions per mile would be similar to the electric vehicle (EV) emissions shown in Table 10-1.

Other Air Toxic Emissions

In addition to carbon monoxide and ozone, there are several other toxic air-borne chemicals (referred to as "air toxics") associated with vehicle fuels. Benzene, toluene, polycyclic organics, and formaldehyde are a few. Benzene, a known potent cancer-causing substance, is present in all Hawaii gasolines. Eighty-five percent of human exposure to benzene comes from gasoline (Durenberger, 1991).

There is increasing concern over the health effects of long-term low level exposure to air toxics; the Clean Air Act Amendments of 1990 name 189 toxic air pollutants, typically carcinogens, mutagens (substances which can cause gene mutation), or reproductive toxins. "For the most part, these chemicals and their potential effects on human health have been known for some time. 'Protect the public health with an ample margin of safety' was particularly controversial in the case of carcinogens, because they pose some risk at even very low emission levels" (Wegman, 1991).

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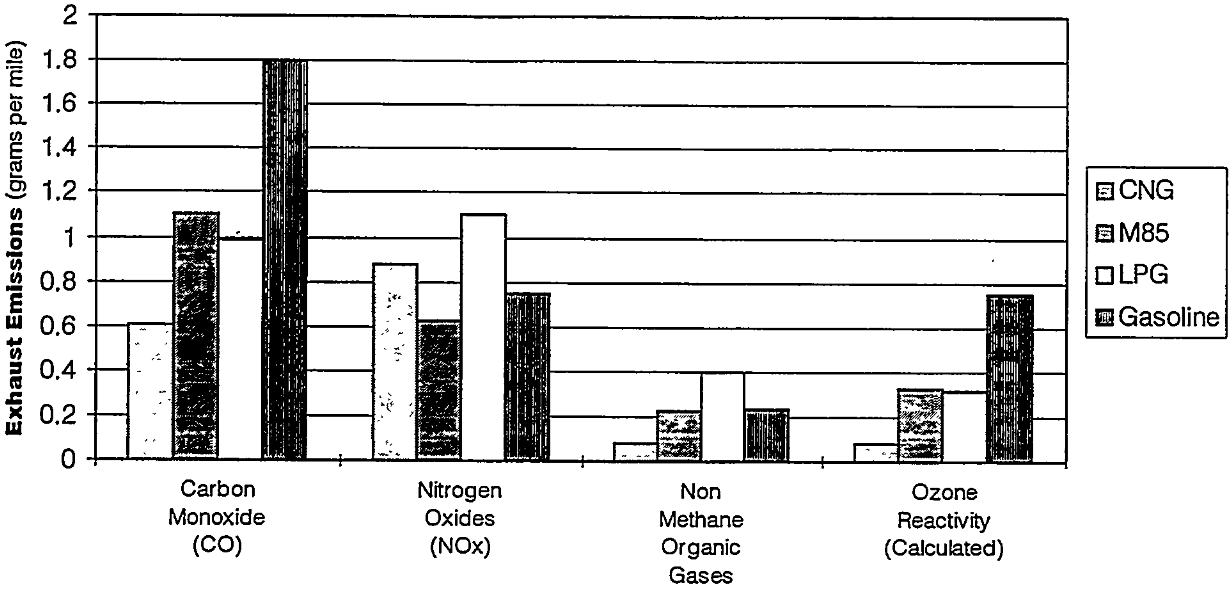
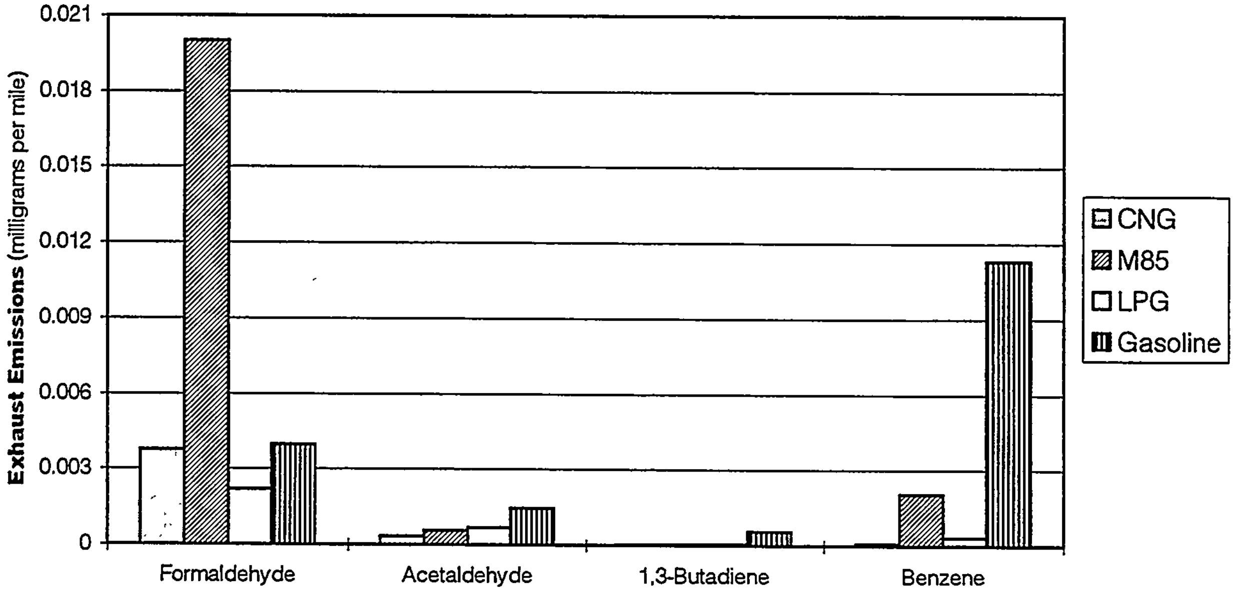
[6] The CleanFleet program, sponsored by USDOE, USEPA, the South Coast Air Quality Management District, the California Energy Commission and private companies, with technical services by Battelle, was a demonstration of panel vans in commercial operation using liquid and gaseous fuel technologies which were available for commercial service in 1992.

Figure 10-1.
Alternative Fuel Vehicle Emissions



Alternative fuel vehicle emissions are different from gasoline, particularly with respect to formaldehyde and acetaldehyde. CleanFleet Program data on toxic emissions was used to generate Figure 10-2.

Figure 10-2.
Air Toxic Emissions from Gasoline and Alternative Fuel Vehicles



The graph above shows total amounts of emissions. However, risk and toxicity are not based on emission mass alone. Benzene, a "Group A" (known human carcinogen) substance, is worse than formaldehyde, acetaldehyde, or 1,3-Butadiene, which are classified as Group B1 and B2 (probable human carcinogens) (USEPA, 1993). Also, each of the toxics have different atmospheric residence times and transformation properties. Weighting factors[7] (based on carcinogenicity and atmospheric residence times) were applied to the above emissions levels to obtain the relative rankings of emissions shown in Figure 10-3.

The emissions data presented up to this point has focused on existing technology. Dedicated alcohol-fueled vehicles, however, would offer even greater emissions benefits than the flexible-fueled vehicles, since they would be optimized to increase fuel economy as well as combustion efficiency; catalysts could also be optimized to remove formaldehyde and acetaldehyde. Estimates of relative emissions from additional types of vehicles are presented in Table 10-1.

10.2.2.2 GREENHOUSE GAS EMISSIONS

Fossil fuels are major contributors to the increasing levels of atmospheric carbon dioxide implicated in global warming. As the situation is described by experts,

> "The amount of carbon dioxide in the atmosphere has been increasing by 0.4 percent a year because of the use of fossil fuels such as oil, gas, and coal ... The net effect of these increases could be a worldwide rise in temperature, estimated at 2° to 6° C (4° to 11° F) over the next 100 years. Warming of this magnitude would alter climates throughout the world, affect crop production, and cause sea levels to rise significantly. If this happened, millions of people would be adversely affected by major flooding." (Microsoft Encarta, 1994)
>
> "An even more fundamental limit *[than supply limitations]* on fossil fuel use is the atmosphere's ability to cope with the burden of nearly six million tons of carbon emissions each year. Scientists predict that these emissions will warm the atmosphere at an unprecedented rate, and may eventually undermine the economy itself. Combustion of all the world's remaining fossil fuels would raise the concentration of carbon dioxide as much as tenfold, compared with the mere doubling that now concerns scientists. Slowing global warming inevitably means placing limits on fossil fuel combustion." (Flavin, 1990)

Fuels from non-fossil fuel sources include fuels made from biomass or generated from solar, wind, and hydropower (for example, abundant hydropower in Canada has been used to produce low-cost hydrogen for use as a fuel). Electricity from a renewable source (e.g. solar, wind, etc.) is also considered a "renewable fuel." Figure 10-4 illustrates the use and production of carbon dioxide (CO_2) from non-renewable versus renewable sources.

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[7] Wang, 1993. Weighting factors used: Benzene, 10; 1,3-butadiene, 9.37; formaldehyde, 1.31; and acetaldehyde, 0.31.

Figure 10-3.
Weighted Air Toxic Emissions from Gasoline and Alternative Fuel Vehicles

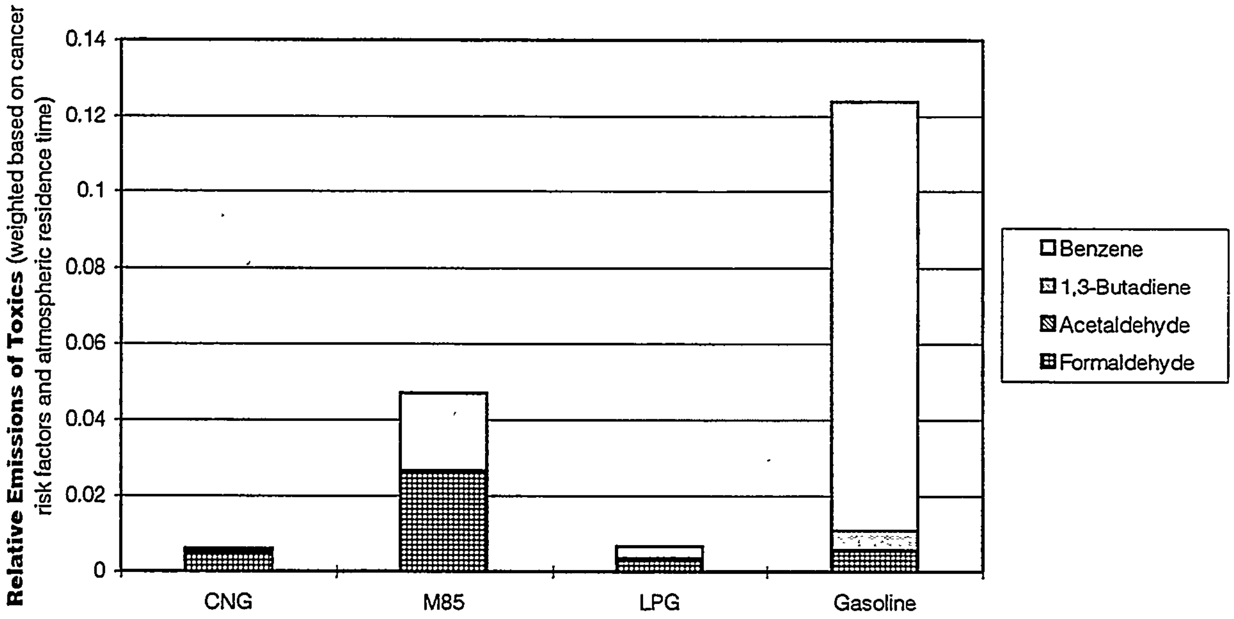
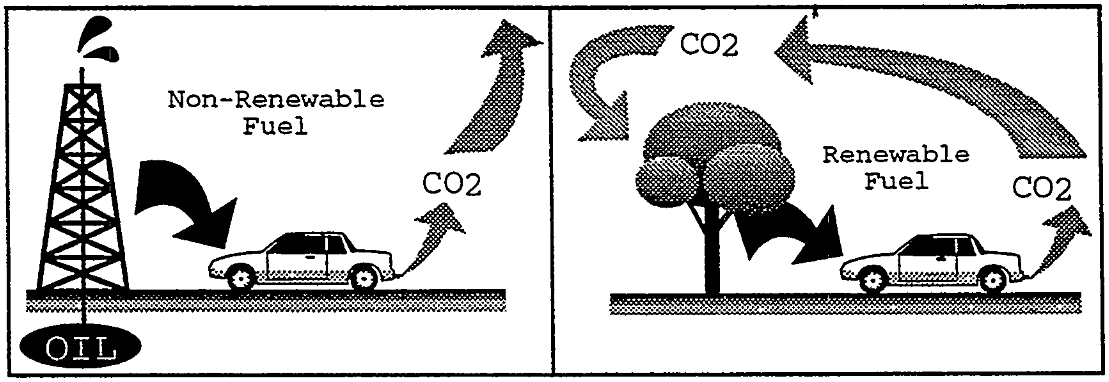


Table 10-1
Alternative Fuel Vehicle Emissions Rates Relative to Gasoline Vehicle Emissions

Vehicle Type	**Exhaust Emissions**						
	CO	**NOx**	**NMOG**	**Benzene**	**1,3-Butadiene**	**Acetaldehyde**	**Formaldehyde**
Gasoline Vehicle, Tier I	100%	100%	100%	100%	100%	100%	100%
M85 FFV	90%	90%	45%	15%	20%	25%	380%
M100 FFV	90%	90%	40%	84%	20%	25%	345%
M85 Dedicated	85%	90%	35%	10%	15%	20%	295%
M100 Dedicated	80%	90%	30%	10%	15%	20%	260%
E85 FFV	90%	90%	70%	10%	20%	925%	140%
E85 Dedicated	85%	90%	65%	5%	15%	760%	128%
LPG Dual-Fuel	70%	100%	30%	5%	5%	50%	115%
CNG Dual-Fuel	70%	100%	10%	1%	5%	35%	170%
CNG Dedicated	60%	90%	10%	1%	5%	30%	140%
EVs	5%	40%	5%	0%	0%	0%	5%

Source: Wang, 1993. E85 dedicated vehicle rates added.

Figure 10-4.
Carbon Cycle for Renewable vs. Non-Renewable Fuels



As illustrated above, the carbon cycle for non-renewable fuels, such as gasoline and diesel fuel from petroleum, involves pumping the fuel out of the ground, processing it into and using it as a fuel, and releasing the products of combustion (including CO_2) into the atmosphere without any subsequent recovery of the CO_2 (thus the increasing accumulation of CO_2 in the atmosphere). The renewable fuel, such as fuel from biomass, also results in the release of CO_2 when the fuel is burned - but in this case, the biomass re-uses the CO_2 as part of its growing cycle.

Actual fuel and carbon cycles are more complex than the simplified diagram above indicates; the processing of materials into fuels, and the growing of energy crops, involve energy inputs of their own, as do transporting of the fuels and even manufacture of the vehicles. Life cycle emissions of greenhouse gases are difficult to quantify; however, alternative fuels in general contribute less net CO_2 to the atmosphere than does gasoline (USDOE, 1994).

10.2.3 LOCAL ECONOMIC BENEFITS

Having examined the long-term goals of energy security and environment, it is instructive to examine the long-term goal of local economic benefits.

There is a general belief that domestic production of alternative fuels, although perhaps more expensive than oil, would provide economic benefits such as new domestic investment and local jobs. This theme underlies the financial incentives in EPACT and recent discussions on domestic production of components of reformulated gasoline.

In Hawaii, economic benefits may be even more significant given the condition of the state's sugar industry. Hawaii's sugar industry declined from 7,282 direct hourly employees in 1980 to 4,453 in 1990, a loss of more than 2,800 direct jobs and approximately 10,000 total jobs given a multiplier of 3.54 associated with this industry (State of Hawaii, Department of Agriculture, 1994). Could alcohol fuels and local production and conversion of EVs stimulate investment and job creation in Hawaii? Would the cost of an alternative fuel program be less than the cost of the economic adjustment required with the continued decline of Hawaii sugar?

Worldwide, the investment required to create jobs ranges from $30,000 to $100,000 (Geller, 1985). If an alternative fuel program in Hawaii could be designed to preserve jobs at costs in this range, such a program may be considered to be competitive with typical options for job creation.

10.2.3.1 ALCOHOL FUELS

As shown in Chapter 8, different options for alcohol importation and production result in different cost projections; generally speaking, higher costs are projected for smaller scales of alcohol demand and the lowest costs are projected for the highest levels of demand. In this study, alcohol importation/production scales were separated into phases as shown in Table 10-2.

Table 10-2.
Phases of Alcohol Demand

ALCOHOL	GEG ALCOHOL FUELS		ALCOHOL DEMAND (gallons of 100% alcohol if all alcohol fuel is methanol)	
PHASE	FROM	TO	FROM	TO (approx.)
1	0	674,716	0	1,000,000
2	674,716	10,120,743	1,000,000	15,000,000
3	10,120,743	30,362,229	15,000,000	45,000,000
4	30,362,229	60,724,458	45,000,000	90,000,000
5	60,724,458	400,000,000	90,000,000	592,841,848

The lowest-cost option (based on mid-range of cost projections) in each phase determines the subsidy amount necessary for alcohol fuels to meet the current price of gasoline on an energy equivalent (GEG) basis in each phase. Results (assuming that fuel taxes have already been adjusted on the basis of energy content) are shown in Table 10-3. Subsidies would only be provided to importers of alcohol fuels in the early phases of the program, and discontinued once adequate quantities of alcohol fuels were being produced in-state.

Consider a large-scale alcohol industry corresponding to substantial petroleum substitution. It could include a 59 million gallon per year (mgpy) fiber-to-methanol plant large enough to attain economies of scale. An alternative fuels program focused on making the methanol produced at this plant competitive for use in M85 vehicles (as compared to gasoline at the pump) would require a subsidy ranging from seven cents per gallon ("low cost" case) to about 42 cents per gallon (average of "low cost" and "high cost" cases) (see Table 10-4).

Table 10-3.
Estimated Alcohol Subsidies for M85 and E85 Fuels to be Competitively Priced in Hawaii

Acohol Fuel Subsidy	**Alcohol Phase 1: 0 to 0.67 million GEG**	**Alcohol Phase 2: 0.67 to 10 million GEG**	**Alcohol Phase 3: 10 to 30 million GEG**	**Alcohol Phase 4: 30 to 61 million GEG**	**Alcohol Phase 5: 61 to 400 million GEG**
for M85/E85 fuels	$/GEG (1)	$/GEG	$/GEG	$/GEG	$/GEG
For fuels not produced in Hawaii	$1.38	$0.90	N/A	N/A	N/A
For fuels produced in Hawaii	N/A	$0.90	$0.73	$0.63	$0.47

1. $/GEG refers to $ per gasoline equivalent gallon. One gasoline equivalent gallon = 1.4 gallons of E85 and 1.74 gallons of M85.

Table 10-4.
Projected Cost of Methanol for Use as M85

Methanol Scenarios	**Methanol Annual Volumes** (gallons 100% alcohol)	**Sold as M85**				
		With GEG-adjusted Taxes (2)		**With Alcohol Fuel Subsidy**		
		Low Pump Price ($/GEG) (1)	**High Pump Price** ($/GEG)	**Low Pump Price** ($/GEG)	**High Pump Price** ($/GEG)	**Average of Low & High** ($/GEG)
M1a. Methanol Imported	6,000	$2.59	$3.22	$1.21	$1.84	**$1.52**
- Containers	170,000	$2.60	$3.23	$1.22	$1.85	$1.54
M1b. Methanol Imported	714,000	$3.34	$4.14	$1.96	$2.77	$2.36
- Parcel Tanker	1,275,000	$2.66	$3.17	$1.28	$1.80	$1.54
	>60,000,000	$1.82	$1.99	$1.82	$1.99	$1.90
M2a. Methanol Made	10,000,000	$1.96	$3.21	$1.05	$2.31	$1.68
from Banagrass				$1.23	$2.49	$1.86
on Oahu	59,000,000	$1.59	$2.72	$0.87	$1.99	$1.43
				$0.96	$2.09	**$1.52**
	184,000,000	$1.52	$2.62	$1.05	$2.15	$1.60
				$1.05	$2.15	$1.60
M2b. Methanol Made from Coal	1,247,000,000	$2.62	$2.62	$2.15	$2.15	$2.15
with electricity co-production	1,247,000,000	$2.00	$2.00	$1.52	$1.52	**$1.52**
M3. Methanol Made	10,000,000	$2.45	$3.80	$1.54	$2.89	$2.22
from Banagrass				$1.72	$3.07	$2.40
on a Neighbor Island	67,000,000	$1.86	$2.99	$1.23	$2.36	$1.80
and Shipped to Oahu				$1.38	$2.52	$1.95
	375,000,000	$1.75	$2.85	$1.28	$2.37	$1.83
				$1.28	$2.37	$1.83

Notes:
1. $/GEG refers to $ per gasoline equivalent gallon. One gasoline equivalent gallon = 1.4 gallons of E85, 1.74 gallons of M85, and 1.03 gallons of E10.
2. Since alternative fuels contain less energy per gallon, more gallons are used to travel the same distance. GEG-adjusted taxes take this into account.
3. Per gallon 100% alcohol produced.

Is such a subsidy cost-effective for job preservation? Investment in one of these plants could, circumstances permitting, preserve 2,000 - 2,500 direct and indirect jobs (derived from the yield-per-acre and employment-per-acre data summarized in Tables 10-5 and 10-6). The jobs associated with such a plant, which would supply about 7 percent of the fuel demand for ground transportation in Hawaii, could offset some of the job loss experienced by the Hawaii sugar industry from 1980 to 1990.

If the fuel was subsidized at the rate of 7 cents per gallon, the cost of the fuel subsidy in that year (assuming all factors, including gasoline prices, remain constant) would be $4,000,000 or about $2,000 per job. If the fuel was subsidized at the rate of 42 cents per gallon, the cost of the fuel subsidy would be $25,000,000 or about $11,000 per job. Whether these would be reasonable or desirable levels of public support depends on the total value to the state of this economic activity and whether these levels of support could be reduced or eliminated as feedstock prices decreased, technology improved, or other conditions changed.

The actual cost of achieving such levels of demand will include elements such as vehicle purchase incentives and/or additional vehicle costs; higher subsidy levels and/or costs in earlier program phases; and research, development, and demonstration program costs.

Table 10-5.
Acreage and Yield for Alcohol Production

Gallons / ton dry matter:					
Methanol from Fiber		Ethanol from Sucrose (1)		Ethanol from Fiber (1)	
150		154		83	
Fiber crop yield (dry tons/acre-year):					
	230,000 acres high-yield land		100,000 acres medium-yield land		
Banagrass	22		18		
Trees	12		10		
Sugarcane crop yield (dry tons/acre-year), high yield land:					
Sugar		Fiber		Both	
6.52		12.57		19.09	
Gallons Alcohol per Acre-Year:					
Banagrass - high-yield land		Banagrass - medium-yield land		Ethanol from Sucrose	Ethanol from Sucrose + Fiber
Methanol	Ethanol	Methanol	Ethanol		
3300	1826	2700	1494	1004	2047
Annual Alcohol Use (2)		**Total Acres Required to Support Demand**			
Methanol demand (mgpy)	Ethanol demand (mgpy)	Methanol-low (Banagrass, high-yield land)	Methanol-high (Banagrass, med-yield land)	Ethanol-low (Sugarcane crop)	Ethanol-high (Banagrass, med-yield land)
5	4	1,515	1,852	1,825	2,501
10	7	3,030	3,704	3,651	5,002
25	19	7,576	9,259	9,127	12,506
50	37	15,152	18,519	18,255	25,012
59	44	17,879	21,852	21,540	29,515
100	75	30,303	37,037	36,509	50,025
125	93	37,879	46,296	45,637	62,531
150	112	45,455	55,556	54,764	75,037
184	138	55,758	68,148	67,177	92,045
300	224	90,909	111,111	109,528	150,074
500	374	151,515	185,185	182,546	250,123

1. Assumes the following conversion efficiencies: sucrose to ethanol, 0.96; cellulose to ethanol, 0.95; hemicellulose to ethanol, 0.42.
2. Gallons of M100 or E100.

As described previously, there are numerous factors affecting the potential demand for alcohol fuels (chief among which is the availability of alcohol-fueled vehicles). As circumstances change, and as more specific program direction and program goals are developed, the tools developed in this project may be used to update and refine the estimates of job creation, total program cost, and cost-effectiveness.

Table 10-6.
Employment Implications of an Alcohol Production Industry in Hawaii

Annual Alcohol Use (1)		Displacement of gasoline and diesel (million GEG)	% of Annual Ground Sector Demand	**Direct+Indirect Labor** (Full-Time Workers) (2, 3)			
Methanol demand (mgpy)	**Ethanol demand** (mgpy)			**Methanol**		**Ethanol**	
				Low	High	Low	High
5	4	2	0.7%	177	217	214	293
10	7	5	1.3%	354	433	427	585
25	19	12	3.3%	886	1,083	1,068	1,463
50	37	25	6.5%	1,772	2,166	2,135	2,925
59	44	29	7.7%	2,091	2,556	2,519	3,452
100	75	50	13.1%	3,544	4,332	4,270	5,851
125	93	62	16.3%	4,430	5,415	5,338	7,314
150	112	75	19.6%	5,316	6,498	6,405	8,776
184	138	92	24.1%	6,521	7,971	7,857	10,766
300	224	149	39.2%	10,633	12,995	12,810	17,553
500	374	249	65.4%	17,721	21,659	21,350	29,254

1. Gallons of M100 or E100
2. To arrive at high/low range of employment, use high and low gallon per acre scenarios. Tree crop scenarios excluded because yields are lower and costs higher for trees, compared with banagrass, rendering tree crops generally less attractive on a statewide basis.
3. Assumes 5650 direct employees and 20000 direct plus indirect jobs per 171000 acres.

10.2.3.2 ELECTRIC VEHICLES

EVs may provide attractive economic opportunities as well. EVs are already being produced in Hawaii, and local production will increase through the Hawaiian Electric Vehicle Demonstration Project (HEVDP). A study identified more than 24,000 direct and indirect jobs in California if EVs were manufactured there to meet the 10 percent zero emission vehicle (ZEV) requirement. Thus, scaling on the relative number of automobiles in California and Hawaii, if EVs could obtain a 10 percent market share in Hawaii, there could be about 1,000 direct and indirect jobs associated with EV production in Hawaii. Although the actual number could be less if Hawaii did not produce all the components, EV production could still create a significant number of jobs in Hawaii.

10.2.4 REFINERY IMPACTS OF SUBSTITUTION

The Hawaii Energy Strategy Project 2, *Fossil Energy Review* (1993) considered the impacts of alternative fuels substitution on the two oil refineries in Hawaii and concluded that even the most aggressive scenario considered in Chapter 4 does not cause seriously negative impacts on the refineries, provided refinery investments are appropriately made. With sufficient government and private sector cooperation, refinery impacts do not preclude an aggressive substitution goal.

10.2.5 SUMMARY

A long-term goal of petroleum displacement of 20-30 percent in the ground transportation sector supports long-term objectives of energy security, environmental protection, and local economic development.

10.3 POTENTIAL ELEMENTS OF AN ALTERNATIVE FUELS PROGRAM

10.3.1 PROGRAM CONSTRAINTS

The following policy questions need resolution at the outset. The discussion below suggests certain policy decisions that have been assumed as the starting point for the program.

1. Should the Hawaii substitution program be "fuel neutral"?

The program should encourage those fuels that provide the most energy security and economic stimulus benefits to Hawaii; the level of support should be directly related to the extent of the benefits and potential benefits which could be provided to Hawaii by the use and production of the fuels. From this perspective, therefore, the program should be "fuel neutral" in the sense that any fuel providing the equivalent amount of benefits and potential benefits as any other fuel should receive the same level of encouragement. The fuels are only a means of meeting the objectives.

Since it appears that electric and alcohol fuels provide the most benefits and potential benefits to Hawaii at this point, they merit the most support; biodiesel, if shown to be feasible at large scale, could also merit a comparable level of support. Propane, although it does not merit financial support, does fulfill a role in helping to meet certain fleet requirements and therefore merits support in terms of publicity and information dissemination.

2. Should indigenous sources be preferred over imports?

Yes, although "secure" imports may have some value. Enhancing the "security" of imports has not been evaluated in this project.

3. Should program funding stay within the transportation sector, or should other economic sectors be included?

It would be preferable to keep the program within the transportation sector, if possible, since the transportation sector is the one whose security is a primary motivation of the program. Consequently, subsidies and other support for alternative fuels should be obtained from users of gasoline, diesel fuel and owners and operators of conventionally fueled vehicles in a "revenue neutral" manner. This is in contrast to "externality fees" which are designed to raise the price of oil to cover its external costs (see Item 4 below).

However, the measures discussed later would result in some revenues from gasoline, diesel, and conventional vehicle taxes and fees flowing to the agricultural sector to encourage alcohol production. Since overall statewide economic benefits are a major goal of the program, and because of the overall benefits of energy diversification, this shunting of funds seems appropriate. Nonetheless, this is a decision that the state must confirm.

4. Should gasoline and diesel fuel carry fees or taxes large enough to "internalize the externalizes," thereby placing the alternative fuels on a "level playing field" with conventional fuels?

The pricing of petroleum does not include all of its "externalities" in its cost basis. Examples of petroleum externalities include defending foreign oil supplies, cleaning up oil spills, and air pollution resulting from petroleum fuels. The externalities of petroleum are legitimate costs, but to date they have been paid by others or not yet paid. Externality fees would perhaps be $1 or more per gallon.[8]

Incorporating externality costs in the price of petroleum fuels is often advocated by theoreticians because it would strengthen "market based" approaches to fuel diversification without further government involvement. If non-petroleum alternatives were cheaper, they would gain a market share. However, full externality pricing of petroleum is not viewed as practical because this level of fees is unlikely, especially at a state level where state businesses facing such fees would be at a substantial competitive disadvantage in comparison with businesses in other states without such fees. Furthermore, the rapid introduction of such a high tax on fuel would probably cause economic disruption and depressed business activity. Also, if the additional revenues were diverted to an alternative fuel program, such pricing would generate more funds than necessary. In sum, although externality fees might have benefits, there would also be severe adverse effects. Therefore, "leveling the playing field" through "externality fees" on gasoline and diesel fuel is not included in the proposed measures.

However, this conclusion does not eliminate the consideration of new taxes on conventional vehicles and petroleum fuels. The fees and taxes would be small compared with the total externality costs, and would serve as revenue generators for the alternative fuels program.

5. How should the level of subsidy be determined?

Subsidies are needed in the near term to begin introduction of alternative fuels. Alternative fuel subsidies[9] can equal the amount needed to achieve price parity or the amount justifiable given the expected benefits of the alternative fuel. Acceptable costs for measures are costs which do not exceed quantifiable program benefits.

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[8] California has recently surveyed the state of knowledge of externality costs for petroleum as part of a statutory required assessment and report. Costs of defending oil and weathering recessions triggered by instability in oil prices appear to be about $20 per barrel. Environmental damage would add some additional costs. Therefore externality costs of around $1 per gallon at the retail level appear to be in the right range, although uncertainties are great and analysts disagree.

[9] In this context, it should be noted again that oil itself is subsidized, since consumers of gasoline and diesel do not pay for many of the externality costs of oil.

6. Should incentives phase out?

Yes, although while subsidies for alcohol fuels and electric vehicles can be reduced over time they probably cannot be eliminated while leaving alcohol and electric at price parity, even at large, cost-efficient scales, with current prices. However, initial subsidy levels are higher than should be needed in later phases, and the reduction of subsidies should occur as production scale increases and technologies improve.

7. Should a program have mostly centrally directed regulatory requirements, or should it be based on market-based approaches?

Generally, mainland programs have attempted to use a mix of requirements and incentives because requirements (such as EPACT fleet purchase requirements) establish certain future conditions on which the private sector may base investment decisions, while incentives provide a valuable supplement to help achieve cost reductions and optimum approaches. A mixed program may be desirable for Hawaii for the same reasons. Some requirements would ensure the pace of the program and provide investor confidence.

8. Should the program focus on the supply of AFVs and alternative fuels, or on the demand of consumers for such vehicles and fuels?

The most successful programs have elements that address both supply and demand. Those providing the supply appreciate help in stimulating demand, and those addressing the demand expect help in assuring supply.

10.3.2 GENERAL DISCUSSION OF MEASURES

10.3.2.1 GENERAL COMMENTS ON ALTERNATIVE FUEL AND VEHICLE MEASURES

Measures to encourage the use of alternative transportation fuels are generally intended to reduce or eliminate the barriers to adoption, shown in Table 10-7, which are faced by the alternative fuels.

Table 10-7.
Barriers Facing Each Alternative Fuel

Fuel	Barrier	
Alcohol	• Infrastructure • Relatively Few Vehicles Suitably Equipped	• Fuel Cost • Consumer Acceptance
Electric	• Vehicle Cost • Infrastructure	• Consumer Acceptance • Standardization
Biodiesel	• Lack Of Locally-Relevant Cost & Production Information	• Fuel Cost • Consumer Acceptance
Propane	• Vehicle Conversion Cost • Fuel Availability	• Consumer Acceptance

10.3.2.2 CATEGORIZATION OF POTENTIAL MEASURES

Potential measures, summarized in Table 10-8, are grouped by type: alternative fuel supply measures, alternative fuel vehicle measures, outreach/education measures, and governmental activities.

Table 10-8.
Potential Hawaii Alternative Transportation Fuel Measures

Type of Measure	Description
Alternative Fuel and Alternative Fueled Vehicle Measures (A)	**Fuels**
	A.1 (*) Alcohol / oxygenate blend requirement for gasoline
	A.2 (*) Address infrastructure issues confronting alcohol and electric
	A.3 (*) Ethanol blending in diesel
	A.4 (#) Special fund for alternative fuel incentives
	A.5 (#) Increase taxes on gasoline and diesel
	A.6 (#) Adjust other fuel taxes on the basis of energy content
	A.7 (#) Alcohol production incentive and alternative fuel property tax exemption
	A.8 (#) Selective state co-investment
	A.9 (#) Selective state loans
	A.10 (#) State purchase and distribution of small volumes of alcohol
	A.11 (#) Periodic report on alternative fuel introduction
	A.12 (#) Reduce alternative fuel costs that are within governmental control
	Vehicles
	A.13 (*) Establish fleet purchase requirements
	A.14 (*) Government Vehicle Allowances
	A.15 (#) Alternative fuel incentive on government contracts
	A.16 (*) Non-discriminatory insurance treatment
	A.17 (#) Special fund for AFV incentives
	A.18 (#) Registration fee surcharge on conventional vehicles
	A.19 (#) AFV purchase/conversion incentives
	A.20 (#) Periodic report on AFV introduction
Outreach and Education (O)	O.1 Continue dialogue with fleet managers
	O.2 Public education
	O.3 Train AFV technicians
	O.4 Loaner AFV program
Governmental Activity (G)	G.1 Encourage full funding of EPACT and EO #12844
	G.2 Address implementation of Act 199, Ethanol Mandate
	G.3 Maintain effective communications with the legislature
	G.4 Work to achieve consensus on an Omnibus Transportation Energy Bill
	G.5 Ensure Hawaii participation in the EV "Infrastructure Working Council"

(*) = Requirement.(#) = Incentive.

Certain measures would require statutory authorization, and for discussion purposes the title "Energy Resources Coordinator" is used as the official responsible for the administration of the program.

10.3.3 INDIVIDUAL MEASURES

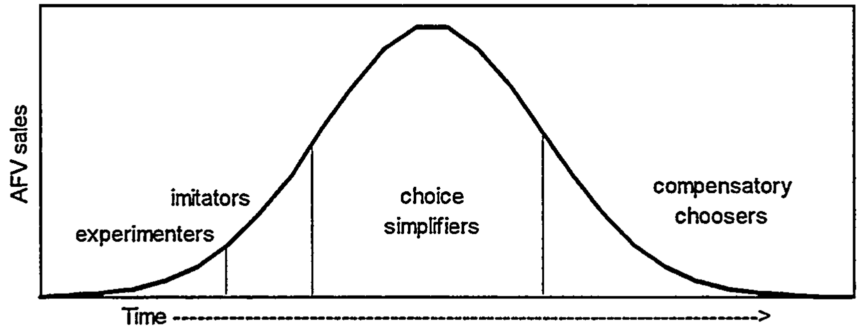
10.3.3.1 ASSUMPTIONS USED IN EVALUATIONS

Estimates of future energy demand are from Chapter 2. Fuel prices at the pump are from Chapter 8. Estimates of alternate fuel vehicle technology adoptions are based on a variety of sources, including work in progress in California (Kavalek, 1995; Turrentine and Sperling, 1992; Train, 1986; Davis, 1995).

Attributes considered in vehicle choice are vehicle price, vehicle range, top speed, acceleration (0-60 mph), luggage space, service station availability, fuel cost, service station refueling time, home recharge time, and vehicle emissions (if attributes for all vehicles are identical, probability of choice of any one will be the same as probability of choice of any other). A vehicle availability factor (what percentage of all the vehicles available are capable of operating or being converted to operate on the alternative fuel) is then applied to the choice probability.

Adoption of new technology is assumed to follow a diffusion process for AFVs (see Figure 10-5) in which early purchasers are experimenters (or, in an environmental consumer market, "moral choosers"), followed by imitators ("social choosers"), and finally (once information on fuels and vehicles has become widely available), choice simplifiers and compensatory choosers.

Figure 10-5.
Diffusion Process for AFVs



Source: Turrentine and Sperling, 1992.

In other words, even if alternative fuel vehicles are available with costs and attributes identical to conventionally-fueled vehicles, consumers unfamiliar with the alternatives will not purchase the new technology. As consumers become more familiar with the alternatives, acceptance will increase; this process of information and technology diffusion will eventually result in consumer behavior which is constrained essentially by vehicle availability, vehicle attributes, and price.

All fleet purchase requirements of the Energy Policy Act of 1992 are included in evaluations. Vehicle and fuel prices are in constant dollars. For more detail, see Appendix A-4.

10.3.3.2 THE "FUTURE NO ACTION" CASE

The "future no action" case assumes that none of the measures discussed below are active. All of the potential alternative fuels are assumed to be available. All fleet purchase requirements of the Energy Policy Act of 1992 are included. The percent of rental cars assumed to resold and retained in the state is 10%. There is no ethanol blending, no adjustment of fuel taxes, no public education efforts by either public or private entities, (except as specifically stated in respective measure evaluations) and all prices are in constant dollars.

10.3.3.3 ALTERNATIVE FUEL MEASURES

The following measures were considered as potential means of promoting alternative fuels and alternative fueled vehicles.

A.1 Alcohol or Other Oxygenate Blend Requirements for Gasoline

A requirement for gasoline to contain alcohol or other oxygenates may take one of two forms: as an alcohol requirement, or as an oxygenate requirement.

One of the primary differences between an alcohol content requirement and an oxygenate requirement is in the requirement's stated objective. With an alcohol content requirement, the intent of the requirement is for alcohol to be used as fuel. The requirement, therefore, may be flexible as long as the goal - use of a certain amount of alcohol as fuel - is met. For example, consider a 5% blending requirement. One possible approach, rather than 5% across the board, would be to have a 10% blend in some gasolines, a 5% blend in others, and possibly 0% in the rest, as long as the overall alcohol use would be the same as a statewide 5% blend. This approach would give consumers a choice and refiners and marketers some flexibility in their distribution and marketing. An oxygenate requirement, on the other hand, would require a certain oxygen content in all the fuel. If ethanol was to be the oxygenate in a 2% oxygen content requirement, for example, all gasolines would contain 5% ethanol. There would be limited opportunity, if any, for gasolines to have 10% ethanol or 0% ethanol, thus allowing even less choice for consumers, refiners, or marketers.

Another potential difference between an alcohol content requirement and an oxygenate requirement is in state excise tax revenues. Since 10% ethanol blends are eligible for the excise tax exemption, and 5% blends are not, the alcohol blending requirement would cost the state more in uncollected excise taxes if the required use of ethanol fuels was made up primarily with 10% blends. Cost estimates for alcohol content requirements assume the highest cost case, i.e. the maximum amount of 10% blends. Cost estimates for oxygenate requirements assume that none of the blends are eligible for the excise tax exemption.

A1a Alcohol Content Requirement

Hawaii could adopt regulations requiring that gasoline sold in Hawaii must contain a certain percentage of alcohol, with discretion by the Energy Resources Coordinator to lower amounts to zero if adequate supplies are not locally available at competitive prices.

Such a measure could create an immediate demand at a scale which could potentially make local fuel production cost-effective. With current gasoline demand in the range of 380 million gallons of fuel, a 10% ethanol blend in 50% of the gasoline would create a demand for about 19 million gallons of ethanol. Or, a 3% methanol blend in 50% of the gasoline would create a demand for about 6 million gallons of methanol. The ethanol or methanol could also be converted into ethers methyl tertiary butyl ether (MTBE) or ethyl tertiary butyl ether (ETBE).

Since interstate commerce laws do not allow states to enact laws inhibiting the free flow of products between states (i.e. there can't be a requirement that gasolines contain only "Hawaii-produced" alcohols), Hawaii-produced alcohol will have to compete with alcohol or ethers from outside the state.

Current state law allows for gasoline blended with 10% biomass-based alcohol to be exempt from the 4% tax on retail sales; the value of this incentive is about 4 cents per gallon of blended fuel.[10] If it appears that out-of-state producers would benefit from the exemption, Hawaii could consider enacting a producer incentive (see Measure A-7).

Impact: Three levels of alcohol blending in gasoline (5%, 7.5%, and 10%) were assessed. Next to fleet mandates, this measure resulted in the highest projected gasoline and diesel displacement of all the measures tested - 3.1%, 4.7%, and 5.3% greater displacement of gasoline and diesel than the "future no action" case. (Even with these amounts of "displacement," the total projected demand for gasoline and diesel in 2014 is greater than total demand in 1994).

This measure also has a small secondary effect on the relative attractiveness of M85 and E85 vehicles. By creating an instantaneous demand for several million gallons of alcohol fuel (i.e. by going directly to the "phase 3" level of alcohol production), the relatively high M85 and E85 fuel costs of alcohol phases 1 and 2 are avoided. This results in about 5% more alcohol vehicles with this measure active than in the "future no action" case.

A1b Oxygen Content Requirement

Hawaii could adopt regulations requiring that gasoline sold in Hawaii must contain a specified percent oxygen by weight,[11] with discretion by the Energy Resources Coordinator to lower amounts to zero if adequate supplies of oxygenates (including ethanol, methanol, and ethers) are not locally available at competitive prices.

The effect of this measure would be to require the use of oxygenates (such as ethanol, methanol, ethanol- or methanol- based ethers, or other oxygenates) in gasoline. Oxygen content requirements could be met in several ways, as shown in Table 10-9. A 2% oxygen requirement could be met with methanol at 3.8%, ethanol at 5.5%, MTBE at 11.1%, or ETBE at 12.9%.

There are other oxygenates, such as tertiary amyl ethyl ether (TAME) and tertiary butyl alcohol (TBA), which are not manufactured from ethanol or methanol but which would meet the oxygenate requirement.

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[10] This incentive is available regardless of where the ethanol used in the gasoline is produced. Some other states have changed their ethanol incentives to be at the point of production rather than at the point of sale, so that only their in-state ethanol producers are receiving the incentives.

[11] EPA regulations do not permit gasolines to contain more than 2.7% oxygen by weight, except for ethanol blends which are limited to 3.5% oxygen by weight.

Table 10-9.
Potential Use of Alcohols and Ethers in Oxygenates

ALCOHOLS			ETHERS		
	Methanol	Ethanol		MTBE	ETBE
%O by wt: 2%			%O by wt: 2%		
% alcohol by volume:	3.8%	5.5%	% ether by volume:	11.1%	12.9%
%O by wt: 2.7%			%O by wt: 2.7%		
% alcohol by volume:	5.1%	7.4%	% ether by volume:	15.0%	17.4%
ALCOHOL USED IN PRODUCTION OF ETHERS					
Methanol in MTBE			**Ethanol in ETBE**		
Gallons methanol / gallon MTBE:		0.338	Gallons ethanol / gallon ETBE:		0.42
%O by wt: 2%			%O by wt: 2%		
% methanol in MTBE gasoline		3.8%	% ethanol in ETBE gasoline		5.4%
%O by wt: 2.7%			%O by wt: 2.7%		
% methanol in MTBE gasoline		5.1%	% ethanol in ETBE gasoline		7.3%

An oxygenate requirement resulting in a 5% alcohol blend (i.e. a 2.0% requirement met with ethanol or ETBE or a 2.7% requirement met with MTBE) was assessed. As with the 5% alcohol blending requirement, this measure resulted in 3.1% greater displacement of gasoline and diesel than the "future no action" scenario. Even with these amounts of "displacement," the total projected demand for gasoline and diesel in 2014 is greater than total demand in 1994.

A.2 Infrastructure Issues Confronting Alcohol and Electric

These measures address the infrastructure issues that impede introduction of the alternative fuels.

A.2.a Infrastructure Development Requirements for Alcohol Fuels

There could be regulations requiring that at least one new or replacement underground tank at commercial and government fueling facilities be compatible with alcohol. Government would develop equipment specifications and guidance to make this program cost-effective and uniform. The State of Hawaii could work with fuel distributors, dispensing equipment manufacturers, vehicle manufacturers, the State of California and the federal Clean Fuels Implementation Task Force to develop consistent hardware specifications.

At the time of installation of new or replacement storage tanks, alcohol-compatible equipment can be chosen at little or no incremental cost. The South Coast Air Quality Management District in California currently has a rule of this type, and the California Energy Commission provides sample equipment specifications. The tank turnover and removal rate in Hawaii is currently quite high, and as additional Federal regulations come into effect (for example, corrosion protection and spill/overflow protection requirements in 1998) (Kwan, 1995), installers of new tanks may voluntarily opt for double walled stainless steel to reduce liability and insurance costs. Double-walled stainless steel tanks are fully alcohol-compatible.

Compared to the "future no action" scenario, this cost element translates into a difference of 6 cents per GEG and an increase in projected 2014 displacement of gasoline and diesel by alcohol of 0.9%.

A.2.b Infrastructure Development Requirements for Electric Vehicles

A.2.b.1 New Construction EV Recharging Requirement

Hawaii Standards for New Construction Could Require the Provision of Recharging Infrastructure for Electric Vehicles.

At the time of new construction is the lowest cost opportunity to provide electric-vehicle charging infrastructure. Since charging standards have not been established, the requirement could be limited at present to the installation of "raceways," trays or tubes through which cable can be pulled later. Not all structures need to be included, but key structures include parking facilities, condominium and apartment complexes, and single family dwellings. Guidance documents and standards, even if not mandatory, would be helpful in developing a uniform infrastructure.

The "Infrastructure Working Council" is reported to be close to agreement on conductive charging standards (220V, 40A and 110V) with defined interfaces. A corresponding standard for inductive charging remains elusive.

Since some EV charging systems use standard 110-V residential service, this requirement would be expected to have little direct impact on the numbers of electric vehicles in use in the near term. This type of standard is more likely to be a secondary effect of a widespread demand for EVs rather than a driver of demand for EVs. However, in the event that "electrical service suitable for EVs" was different from standard 110-V residential service, and a requirement for such service was applied to all new single-family residential construction, the impact would be equal to the number of new single-family residences constructed, or approximately 4400 - 6800 statewide per year (DBEDT, 1994).

A.2.b.2 Off-Peak Recharging For Electric Vehicles Available At A Reduced Rate

Reduced rates for off-peak electric vehicle recharging could be proposed by the electric utilities and approved by the Public Utilities Commission.

Since off-peak and off-grid charging of electric vehicles is desirable from a load management standpoint, and off-peak charging is preferable to on-peak charging, rates and systems which are designed to maximize off-peak and off-grid charging of electric vehicles could result in both reduced costs for electric vehicle recharging and in increased public awareness and support of electric vehicles.

Impact: off-peak recharging rates, and the use of recharging equipment and/or timers supplied by the electric utility, results in a projected reduction in electricity cost per mile of up to 66% and an increase in the projected 2014 displacement of gasoline and diesel by electricity of 25%.

A.2.b.3 Rate Payer Support for Electric Vehicle Recharging Infrastructure

The Hawaii Public Utilities Commission could allow electric utilities to put into the rate base their costs for public and private recharging infrastructure, electric

battery change out and/or charging facilities and vehicle batteries that are owned by them.

This measure financially supports electric vehicles as they benefit the utility through better load profiles and more efficient power transmission. Utilities would include specific proposals in their applications for rate approvals. The applications would include detailed justifications based on future rate payer benefits.

Although not specifically evaluated at this time, once the electric utilities have developed cost estimates, the impact and effectiveness of this type of measure may be estimated using analysis tools such as those developed in this project.

A.2.c Public Access to Government Fueling Facilities

State and local government facilities that supply alternative fuels could be available to the public, and Hawaii could work with the federal government to provide public access to federal facilities that dispense alternative fuels.

Due to EPACT and Executive Order (EO) 12844 requirements, governments will be establishing facilities to provide alternative fuels to their fleets. Providing public access to these facilities in the early phase of an alternative fuel program would increase the public's willingness to purchase AFVs during the time that private sector alternative fueling facilities are limited in number. Fueling systems are expensive and should serve the maximum number of vehicles possible until alternative fuel and infrastructure becomes more widespread. The federal government is working to revise constraints that limit federal fueling facilities to government fleets. Public access to alternative fueling facilities are features in some Clean Cities programs (e.g. Washington, D.C.).

A.3 Ethanol blending in diesel ("diesohol").

Ethanol could be blended in amounts up to 30% in diesel fuel.

Effect would be to increase use of alcohol fuels. Impact: 5% alcohol in diesel results in a projected increase in 2014 alcohol use of 14% over the "Future no action" scenario; 10% alcohol in diesel results in a projected increase of 28%; and 30% alcohol in diesel results in a projected increase of in 2014 alcohol use of 84% over the "future no action" scenario.

A.4 Special Fund for Alternative Fuel Incentives

Hawaii could establish a special fund ("Alternative Fuel Incentive Special Fund") which would receive revenues from the taxes described in Measure A.5 and from returns of capital, dividends, and interest earned from investments and loans made pursuant to Measures A.8 and A.9.

Since revenues are needed to fund the alternative fuel incentives, funds collected for the alternative fuels program could be separated from the general fund, so that the revenues could be directed to specifically support alternative fuel programs.

Measures A.5, A.8 and A.9 describe the sources of revenues to fund the incentives. The fees would be scaled to program needs.

A.5 Increase Taxes on Gasoline and Diesel Fuel

Hawaii could increase taxes on gasoline and diesel. Funds would be deposited in the Alternative Fuel Special Fund. Hawaii could reauthorize the added taxes after about 6 years based upon a review of the uses of the funds and the effectiveness of the alternative fuel incentive programs (see Measures A.11 and A.20).

The increase in taxes, if any, is not expected to be a disincentive to continued use of gasoline and diesel fuel (for example, fully funding importation and production of alcohol fuel for use in high level blends would require less than one tenth of one cent per gallon for the first ten years). Impact from an energy standpoint, therefore, is equal to the impact of whatever incentives are funded by this measure. These fees and taxes are scaled to supply funds needed to support alcohol production (see Measures A.7, A.8, A.9, and A.10). Funds could also be available to support the electric vehicle program.

A.6 Adjust Other Fuel Taxes on the Basis of Energy Content

Hawaii could ensure that state and local highway taxes on motor fuels would be on an energy-equivalent basis.

This would remove a disincentive to alternative fuels while maintaining the amount of revenue received by the state highway fund from state highway taxes. Since this measure does not require revenue from any other sources, it would be logical for this recommendation to be implemented prior to any other revenue related measures. Impact of this measure on fuel prices is 27¢ per GEG for M85, 16¢ per GEG for E85, and 20¢ per GEG for E100.

A.7 Alcohol Production Incentive

Hawaii could establish a producer payment for local producers of alcohol fuels.

At current gasoline prices and with the costs projected in this study, it appears that alcohol fuel production incentives would be necessary in order for high-level alcohol blends (E85, M85, E100, M100) to be attractively priced; lower-level alcohol blends (E10) may also benefit from production incentives, depending on the situation. Alcohol producer incentives for high-level and low-level blends are discussed separately below.

A.7.a Alcohol Producer Incentive for High Level Blends (M85 and E85)

The "high level alcohol blend producer payment" scenario evaluates the impact of payments to local producers (or importers, in phases 1 and 2) in amounts sufficient for alcohol fuels to be competitive (on a GEG basis) with gasoline costs at the pump. Rates are adjusted by alcohol phase (see Table 10-2) to correspond with expected cost decreases associated with larger alcohol plants.

Note: the "producer payment" is not a "tax credit." The ability of a traditional "tax credit" to provide the necessary level of subsidy is questionable, since tax credits are only applicable to the amount of tax owed. If an alcohol producer has a tax liability which is less than the amount of "tax credit" for which he is eligible based on the production of fuel alcohol, then he does not receive the full value of the tax credit.

For example, consider the scenario in which a subsidy of 61 cents per gallon of ethanol is required in Phase 3 for E85 to compete with gasoline at the pump. A tax credit of 61 cents would not provide that amount of support. In order for the alcohol producer to receive $0.61 in tax credits per gallon of alcohol produced, with a production cost of[12] $1.40 per gallon, the producer would have to owe $0.61 per gallon in state income taxes. The only way he'd owe that much in state taxes (assuming 6.435% state tax rate on corporate taxable income) is if he made a net profit of $9.48 per gallon (i.e. he'd have to sell it for at least $10.88). If the alcohol could be sold for that much, a production incentive wouldn't be necessary. Therefore, a production incentive would have to be either a direct payment to the producer or some form of marketable tax credit which could be sold by the producer to an entity which would be able to use the tax credit certificate to offset taxes owed.[13]

Impact: subsidizing the M85/E85 fuel to be the same price per GEG as gasoline translates into a difference in alcohol fuel price of $1.70 per GEG (to start), $1.10 per GEG (2001-2012), and $0.92 (2012-2014). In order to fund this measure, a tax of $0.001 (until 1999), $0.002 (2000-2002), $0.007 (2002-2005), $0.013 (2006-2009), and $0.020 (2010-2012) per gallon of gasoline and diesel would provide the necessary revenue.

Note: if a scenario includes both low-level ethanol blending (as in Measure A.1), and alcohol producer payments designed to subsidize alcohol production so that M85 and E85 fuel are the same price as gasoline, program costs rise substantially. This is discussed further in the next section.

A.7.b Alcohol Producer Incentive for Low Level Blends (E10)

As shown in Table 10-10, projected low-level ethanol blend costs range from a low of $1.46 to a high of $1.71. The range of costs are due to variations in the cost of the ethanol; since the ethanol is only 10% of the total fuel, an observed difference of 1 cent indicates that the ethanol price difference is about ten cents. Therefore, if the ethanol blend is one cent more than the non-blended gasoline, a subsidy of ten cents per gallon of ethanol would be required; likewise, of the ethanol blend is three cents more, a subsidy of thirty cents would be required. If the ethanol has a "negative" subsidy (i.e. profit-making potential) of ten cents, that translates into one cent difference in blended fuel price at the pump.

Producer incentives geared towards making E10 competitive with non-ethanol-blended gasoline or with mainland ethanol would be determined based on the scale of production and demand. The tools developed in this project can be used to provide a general evaluation for a specific situation. Producer credits for E10 were not explicitly evaluated here (results would be similar to Measure A.1.a).

A.8 Selective State Co-Investment

The state could co-invest up to 40 percent ownership in alcohol production facilities, alcohol distribution infrastructure, and electric vehicle manufacturing or conversion or battery recycling facilities placed into service after a certain date. Investment funds would be drawn from the Alternative Fuel Special Fund. Dividends and distributions of capital and other payments would be deposited in the Alternative Fuel Special Fund.

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[12] low end: $0.78; high end: $2.02; mid-range: $1.40

[13] Kansas, Missouri, Nebraska, South Dakota, and Minnesota have "direct producer incentives" of 20 cents per gallon for fuel ethanol produced in their respective states. The Minnesota incentive increases in 1995 to 25 cents per gallon, not to exceed $3.75 million per producer per year. Montana has a 30 cent per gallon producer payment for ethanol produced in the state.

Table 10-10.
Alcohol Production Incentives for Ethanol for Use in E10

PHASE	SCENARIO	$/gal E10 (low end)	$/gal E10 (high end)	$/gal gasoline	Subsidy (1) for midrange to be competitive	ACRES	# OF JOBS
1	Ethanol (6000 gpy, containerized) Shipped from Mainland, Sold as E10 (E1b)	$1.66	$1.71	$1.62	$0.61	0	0
1	Ethanol (170000 gpy, containerized) Shipped from Mainland, Sold as E10 (E1b)	$1.62	$1.66	$1.62	$0.17	0	0
2	Ethanol (7 mgpy) from Waste on Oahu, Sold as E10 (E2b)	$1.48	$1.60	$1.62	($0.82)	0	17
2	Ethanol (1 mgpy) from Molasses, Shipped to Oahu, Sold as E10 (E3b)	$1.61	$1.67	$1.62	($0.96)	0	2
2	Ethanol (3 mgpy) from Molasses, Shipped to Oahu, Sold as E10 (E3b)	$1.53	$1.56	$1.62	$0.22	0	7
2	Ethanol (7 mgpy) Produced from Sugarcane on Oahu, Sold as E10 (E4b)	$1.51	$1.65	$1.62	($0.74)	3,420	400
3	Ethanol (30 mgpy) from Waste on Oahu, Sold as E10 (E2b)	$1.46	$1.58	$1.52	$0.50	0	73
3	Ethanol (30 mgpy) Produced from Sugarcane on Oahu, Sold as E10 (E4b)	$1.49	$1.63	$1.52	$0.35	14,655	1,714

(1) $/gal 100% alcohol

State co-investment may be a useful supplement to tax credits for fuel production and distribution because not all production and distribution facilities would generate profits against which credits may be taken. This difficulty faces the federal alcohol mixtures credits and pure alcohol credit as discussed in Chapter 8. Therefore other state assistance may be helpful in the early years of the program. The state may wish to develop criteria for making investment decisions and/or conduct competitive funding programs. The state may also wish to sell or liquidate investments after a period.

For an alcohol production facility with capital costs of $92 million and production capacity of 30 million gallons per year, a direct investment of 10% of facility cost could translate into a difference in fuel production cost of 3 cents per alcohol gallon, or 6 cents per gasoline equivalent gallon.

Outright grants may occasionally be appropriate to cover such items as capital costs at retail alcohol facilities, especially if existing equipment is not compatible with high level blends, or if new tanks need to be installed. This option may need to be used in the early years. It has proven essential in the California program, where grants of up to $30,000 have been extensively used for the first 50 methanol outlets. Grants are the simplest and most effective way to enlist the support of the fuel retailers.

A.9 Selective State Loans

The state could offer from the Alternative Fuel Special Fund low-interest loans for alcohol production facilities and electric vehicle manufacturing, conversion or battery recycling facilities up to an amount that matches commercial and private

loans for the facility. Payments of interest and repayments of principal would be deposited in the Alternative Fuel Special Fund.

This assistance could be a useful supplement to other alcohol incentives. As with investments, the state may wish to develop criteria for making loans and conduct competitions for available funds.

A.10 State Purchase and Distribution of Small Volumes of Alcohol

Using the Alternative Fuel Special Fund, the Energy Resources Coordinator could purchase small volumes of alcohol for bulk facilities or retail stations to ensure that alcohol vehicles could purchase fuel during the early years of the program. The Energy Resources Coordinator would establish a price for this government-supplied fuel at levels low enough that terminals and retailers could provide alcohol fuels at prices competitive with gasoline or diesel fuel and still earn a reasonable margin. The Energy Resources Coordinator would not provide alcohol fuel under this program if alcohol production incentives were being paid for volumes adequate to supply the alcohol fuel demand in any year.

This element could provide alcohol fuels to early vehicles when local production may not be adequate. Alcohol vehicles cannot be marketed successfully if some alcohol fuel is not conspicuously available. This approach would be most appropriate in the situation where local demand for alcohol fuels is less than could support a local production facility (i.e. less than three to seven million gallons per year). Funds collected from the fuel tax (amounts would be identical to the "producer payments without ethanol blending" scenario discussed above) would be used for purchasing alcohol from out of state, with the intent that once the demand for alcohol fuels increased to the point where a local industry could be supported, the funds would be used for payments to local producers. Impact on fuel use over the period of government involvement would be similar to impact of other measures subsidizing the cost of alcohol.

A.11 Periodic Report on Alternative Fuel Introduction

Every two years after the initiation of the fuel incentive program, the Energy Resources Coordinator could report to the legislature on the disposition of funds from the Fuel Incentives Special Fund, the surplus in the Fund, the technologies receiving incentives and support, the numbers of AFVs receiving incentives, incentives requested that could not yet be funded, the technologies being introduced into the vehicle population, the types and amounts of alternative fuels being produced and used in Hawaii (including blends), the amount and net costs of alcohol fuel supplied by the state, and the effectiveness of the incentives in influencing the production and use of alternative transportation fuels in Hawaii. The Energy Resources Coordinator could recommend changes needed to the fees and incentives to achieve the displacement and fuel mix objectives.

The authorizing legislation should allow some discretion to the Energy Resources Coordinator and anticipate the possible need for mid-course changes. The advice of the Energy Resources Coordinator, based on program experience, should be available during consideration of program changes. This measure should be coordinated with A.20.

Portions of the report could be made available to the public and media as well. This, in combination with other "public awareness" measures, is projected to result in a reduced length of time for the acceptance of the new vehicle technologies. See Measure O.2.

A.12 Reduce Alternative Fuel Cost Components That Are Within Governmental Control

The state has control over some of the cost components of the price of alcohol at the pump. For example, an alcohol marine terminal could be located on land leased from the state. Discounts on the rent would help decrease the delivered price of the alcohol.

10.3.3.4 ALTERNATIVE FUELED VEHICLE MEASURES

The following measures should be considered if Hawaii wishes to increase the number of AFVs in use.

A.13 Establish Fleet Purchase Requirements

Hawaii could require fleets to purchase AFVs when adding or replacing vehicles. Fleet requirements for fleets other than state government fleets could be determined through a rule making process. The purchase requirements could be in excess of those imposed by EPACT and apply regardless of whether there are incremental vehicle or fuel costs.

The "aggressive" scenario of Chapter 4 assumes private and rental fleets purchase large numbers of AFVs and resell some portion of them within the state. Local rule making would include assessment of factors such as model availability, retail prices, and resale practices. California's experience indicates that rental companies can accept alcohol vehicles, but the period of mutual education between government agencies and rental companies has covered several years. Furthermore, the rental companies are currently exempted from EPACT requirements and have strongly resisted rule requirements for fear of being dragged into EPACT requirements. Rental company elements of the program could perhaps begin with incentives only. (For an evaluation of incentives, see Measure A.19.)

A fleet purchase requirement could also include a purchase requirement for EVs, to be phased in after the completion of the HEVDP. In particular, government and electric utility fleets may be appropriate targets of an EV purchase requirement.

Requirements for heavy-duty fleets could also be developed by rule making since the number of alternative-fuel heavy-duty engines is currently limited and special circumstances (such as operational requirements for TheBus) need to be addressed. The heavy-duty rule could be revised at frequent intervals as commercial alternative-fuel engines become more common.

A.13.a Establish alternative fuel purchase requirements for state fleets.

Administrative Directive 94-06 directs that 25 percent of motor vehicles acquired (for state government use) in model year 1998 shall be alternative-fueled vehicles. Although this results in an accelerated purchase of vehicles for the first few years, by 2014 the EPACT-required purchases in the "future no action" scenario have almost completely overshadowed state requirements (the net difference in 2014 in number of AFVs due to the state-mandated 25%

level of AFV purchase is 1.2%). A state-mandated level higher than EPACT requirements, however, would show a larger difference.

A.13.b Establish alternative fuel purchase requirements for county fleets.

Although not quantified, county governments could acquire alternative fuel vehicles in excess of those required by the National Energy Policy Act of 1992. The model which has been developed is capable of estimating costs and impacts of various levels of alternative fuel light duty vehicle purchases.

A.13.c Establish alternative fuel purchase requirements for rental and other private fleets.

The National Energy Policy Act of 1992 contains mandates for certain fleets; those mandates are included in the "future no action" scenario. Whereas EPACT fleet mandates apply only to "covered fleets," for the purposes of this evaluation it was assumed that state mandates, shown in Table 10-11, would apply to all rental and private non-rental fleets containing more than ten vehicles.

Fleet mandates alone (no fuel or vehicle incentives), assuming 100% compliance,[14] result in overall displacement of gasoline and diesel in 2014 of 15%, as compared to the "future no action" case of 5%.

Table 10-11.
Fleet Mandate Rates Used for Measure A.13.c

Year	Rental fleets	Private non-rental fleets	EPACT
	percentage of new vehicles required to be AFVs:	percentage of new vehicles required to be AFVs:	requirement for non-government "covered fleets"
1995	0%	0%	0%
1999	5%	20%	20%
2003	10%	40%	40%
2007	20%	70%	70%
2009	25%	70%	70%
2011	30%	70%	70%
2015	40%	70%	70%

The cost to fleets could be significant if the vehicles and / or fuels are more expensive than their gasoline counterparts - with the scenario assumptions, for example, the additional cost in 2014 is estimated at $214 per alternative fuel vehicle (vehicle purchase cost plus fuel cost).

A.13.d Establish purchase requirements for heavy duty vehicles.

Although purchase requirements for heavy duty vehicles were not specifically evaluated in this study, heavy duty vehicles could utilize significant amounts of alternative fuels. Evaluation of the potential cost and potential fuel use by heavy duty vehicles would require that a heavy duty vehicle component, including information on replacement rates, range and engine size requirements, and engine availability and cost, be added to the bus component currently in the model.

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[14] A state mandate requiring private fleets (rental and non-rental) to purchase alternative fuel vehicles would involve a variety of issues.

A.14 Government Vehicle Allowances

State and local government allowances for vehicle leasing by government employees could be provided only for AFVs, and employees choosing gasoline or diesel vehicles would not receive an allowance.

Government officials driving non-fleet vehicles could be conspicuous participants in an alternative fuel program, especially if fleet purchase requirements are adopted. This would contribute to "public awareness" (see Measure O.2).

A.15 Alternative Fuel Incentives on Government Contracts

The evaluation process of bids for government contracts could include provisions to reward those bidders that provide evidence of an effective program to purchase AFVs and use alternative fuels.

This kind of program is being implemented by cities in the Coachella Valley of California as part of a broad alternative fuels program. It appears to be quite effective in publicizing the program and increasing the number of AFVs. Requirements and approaches in Hawaii would be developed locally. The preference could be similar to that for minority or disabled veteran employment or "small businesses."

Where government agencies obtain rental cars under a contract arrangement, a suitable incentive could be applied to daily rental fleets bidding for government business.

A.16 Non-Discriminatory Insurance Treatment

Hawaii could prohibit insurance surcharges on AFVs until statistical data are available to support extra premiums.

Insurance companies sometimes approach AFVs with conservatism. This can discourage a program significantly by adding extra costs and could be avoided until data are available to justify higher premiums. This may require state regulation.

A.17 Special Fund for AFV Incentives

Hawaii could establish a Special Fund ("Alternative Fuel Vehicle Special Fund") to encourage the purchase of alternative fuel vehicles.

Financial incentives would assist vehicle manufacturers, dealers, and fleets, particularly in early years, when the number of AFVs is small and their costs may exceed gasoline and diesel vehicles. In the early years it may be possible to manage the program solely on the basis of incentives rather than requirements to purchase AFVs. A special fund could be set up to finance the incentives.

The intent of this measure is to increase voluntary procurement of alternative fuel vehicles by reducing the costs of alternative fuel vehicle ownership. Impact: see Measure A.19.

A.18 Registration Fee Surcharge on Conventional Vehicles

Hawaii could establish a registration fee surcharge on all gasoline and diesel vehicles. Receipts would be deposited in the Alternative Fuel Vehicle Special Fund.

Hawaii could require that the surcharge be reauthorized after 6 years after a review of reports describing the sources and uses of funds (see Measures A.11 and A.20).

The increase, if any, in registration fee is not expected to have any measurable impact as a direct disincentive to continued purchase of gasoline and diesel vehicles. Impact, therefore, is equal to the impact of whatever incentives are funded by this mechanism (see Measure A.19). Funding requirements may be estimated based on fuel and vehicle availability and cost.

A.19 AFV Purchase/Conversion Incentives

Out of the Alternative Fuel Vehicle Special Fund, Hawaii could provide financial incentives to purchase AFVs. The incentive for light-duty and medium-duty alcohol vehicles up to 33,000 pounds could be $500 per vehicle. For heavy-duty alcohol vehicles above 33,000 pounds the incentive could be $5,000 per vehicle. The incentive to purchasers of electric vehicles could be $2,000 per light-duty and medium-duty vehicle (battery or fuel cell) up to 33,000 pounds and $5,000 for larger vehicles. A rebate of $1,000 could be provided to those who convert a gasoline or diesel vehicle to dedicated battery-electric or fuel-cell drive, if the fuel cell uses alcohol or hydrogen. Hawaii could provide an extra $500 rebate for the purchase of new light-duty AFVs to those who retire pre-1980 light-duty gasoline vehicles.

Alcohol vehicles are generally offered by manufacturers at prices equal to equivalent gasoline-only models. However, a financial incentive is helpful, especially in association with fleet purchase requirements, since fleets may have to buy different models than they might have preferred depending on the alcohol-capable models being offered. Furthermore, manufacturers prefer to see state support for alternative fuel programs, partly as a way to recruit the enthusiasm and active participation of dealers. California has been providing $400 and $500 incentives recently for alcohol passenger vehicles, which has seemed to be adequate, or even perhaps slightly more than necessary to meet the objectives. Large vehicles with diesel-type heavy-duty engines need larger incentives due to the higher costs of these engines, the small volumes, and the relative immaturity of the alcohol technologies in heavy-duty engines.

The needed incentives for electric vehicles are difficult to gauge due to their rapid development. The incentives provided by EPACT are already significant and additional incentives may be available through utility programs (see Measure A.2.B.2). For electric vehicles in the near term, an incentive for conversions is helpful also.

Unlike the alcohol producer incentive, which is set equal to whatever amount is necessary for alcohol fuels to be cost equivalent with gasoline, the vehicle purchase / conversion incentive is an amount which may be more or less than the cost differential between alternative fuel vehicles and their gasoline counterparts.

All incentives were modeled with the following phase-out schedule:

Table 10-12.
Phase-Out Schedule Used for Vehicle Purchase Incentives

Phase	From (year)		To (year)	% of original credit
1	1995	-	1999	100%
2	1999	-	2002	75%
3	2002	-	2005	50%
4	2005	-	2009	35%
5	2009	-	on...	0%

Phase-out schedules may be adjusted, based on incentive levels and projected vehicle purchase numbers, to maintain program (and funding) balance. In an aggressive program (rather than the "incentives only" scenario modeled here) with widely-available alternative fuel vehicles, attractively-priced alternative fuels and fleet mandates, the phase-out schedule shown above may be too slow, resulting in large fees being assessed on an increasingly smaller number of conventional vehicles. In the scenario runs later in this Chapter, incentive phase-out schedules are adjusted to maintain program balance.

Since, in these measure evaluations, a majority of the projected alternative fuel vehicle purchases are by government agencies (which are not eligible to receive the incentives), the costs (and effects) of stand-alone incentive programs are limited. Results are shown in Table 10-13. These results used a common basis of assumptions about vehicle technology, cost, and consumer preference. Scenarios may be run using different sets of assumptions.

The incentive assumed for comparison of this measure with other measures was $500 per alcohol fueled vehicle and $2000 per electric vehicle, with the stated phase out rates.

Table 10-13.
Percentage Change in Cumulative Number of AFVs in 2014 Under Various Vehicle Purchase Incentive Levels

Incentive	Alcohol Vehicles	Electric Vehicles	Propane Vehicles
None	0.00%	0.00%	0.00%
$500 per alcohol vehicle	0.24%	-0.13%	-0.14%
$1000 per alcohol vehicle	0.48%	-0.25%	-0.28%
$2000 per alcohol vehicle	0.96%	-0.51%	-0.56%
$5000 per alcohol vehicle	2.41%	-1.27%	-1.40%
$500 per electric vehicle	-0.09%	0.35%	-0.07%
$1000 per electric vehicle	-0.17%	0.69%	-0.13%
$2000 per electric vehicle	-0.34%	1.40%	-0.27%
$5000 per electric vehicle	-0.88%	3.58%	-0.69%

The incentive assumed for comparison of this measure with other measures was $500 per alcohol fueled vehicle and $2,000 per EV, with the stated phase out rates.

An additional incentive could also be available for older vehicles that are scrapped, but the incentive should only be available as a credit against the purchase of a new alternative fuel vehicle. This incentive could help enlist the support of vehicle dealers for the program, and help communicate the idea that the vehicle fleet could change, as it renews, to include AFVs. The potential impact of a scrappage incentive was not evaluated.

A.20 Periodic Report on AFV Introduction

Every two years after the initiation of the vehicle incentive program, the Energy Resources Coordinator could report to the legislature on the use of the Alternative Fuel Vehicle Special Fund, the mix of technologies receiving incentives and rebates, the numbers of AFVs receiving incentives, the mix of technologies being introduced into the vehicle population, and the effectiveness of the incentives in influencing consumer choices. The Energy Resources Coordinator could adjust the fees and incentives to help Hawaii achieve its displacement and fuel mix objectives.

At the statutory level, the legislature could define the overall objectives and structure of the program. Due to uncertainties in costs and the likelihood of continuing development in technologies, the Energy Resources Coordinator could have latitude to adjust the program features as conditions change.

This measure also helps to maintain public and legislative awareness, which is projected to, in combination with other "public awareness" measures, result in a reduced length of time for the new technology acceptance process. See Measure O.2.

Personnel Requirements

Each of the above measures would require personnel at the state government level to be responsible for implementation; staffing requirements are estimated in Table 10-14.

Mandates and requirements involve both rulemaking and enforcement; these types of measures have the highest staffing requirements (next to measure A.2.C, which would require sales and bookeeping functions at each location). Incentives, although also requiring significant administrative effort, require less in the way of enforcement since only those applying for the incentives need comply with the requirements. Measures such as grants, loans, and public outreach are somewhat more flexible.

10.3.3.5 OUTREACH/EDUCATION

The following outreach and education measures could be pursued.

O.1 Continue Dialogue with Fleet Managers

It is important to continue the dialogue with fleet managers, who are natural targets of AFV programs, particularly transit operators. This dialogue is necessary to ensure that fleet operator concerns are addressed as the program evolves. This measure, in combination with other "public awareness" measures, is projected to result in a reduced length of time for acceptance of the new vehicle technologies. See Measure O.2.

Table 10-14.
Estimated Staffing Requirements for Alternative Fuel and AFV Measures

Measure #	Description of Measure	Initial	Ongoing
A.1	Alcohol or Other Oxygenate Requirement for Gasoline	1.00	0.25
A.2.A	New or Replacement Fueling Facilities to be Alcohol-Compatible	0.35	0.00
A.2.B.1	Require New Construction to Include Electrical Service Suitable for EVs	0.10	0.00
A.2.B.2	Off-Peak Recharging for Electric Vehicles Available at a Reduced Rate	0.05	0.00
A.2.B.3	Ratepayer Support for Electric Vehicle Recharging Infrastructure	0.05	0.00
A.2.C	Public Access to Government Fueling Facilities	30.00	26.00
A.3	Ethanol Blending in Diesel ("Diesohol")	3.00	0.25
A.4	Special Fund for Alternative Fuel Incentives	1.00	1.00
A.5	Increase Taxes on Gasoline and Diesel Fuel	0.20	0.10
A.6	Adjust Other Fuel Taxes on the Basis of Energy Content	0.10	0.00
A.7.A	Alcohol Producer Payments	2.00	1.00
A.8	Selective State Co-Investment	1.00	1.00
A.9	Selective State Loans	0.50	0.50
A.10	State Purchase and Distribution of Small Volumes of Alcohol	3.00	1.00
A.11	Periodic Report on Alternative Fuel Introduction	0.04	0.04
A.12	Reduce...Cost Components...Within Governmental Control	0.05	0.05
A.13.A	Establish Fleet Purchase Requirements for State Government Fleets	0.50	0.10
A.13.B	Establish Fleet Purchase Requirements for County Government Fleets	0.10	0.00
A.13.C	Establish Fleet Purchase Requirements for Private Fleets	3.00	0.50
A.13.D	Establish Purchase Requirements for Heavy Duty Vehicles	1.50	0.25
A.14	Government Vehicle Allowances	0.10	0.01
A.15	Alternative Fuel Incentives on Government Contracts	0.50	0.20
A.16	Non-discriminatory Insurance Treatment	0.01	0.01
A.17	Establish a Special Fund for AFV Incentives	1.00	1.00
A.18	Registration Fee Surcharge on Conventional Vehicles	0.20	0.10
A.19	AFV Purchase / Conversion Incentives	0.50	0.25
A.20	Periodic Report on AFV Introduction	0.04	0.04

O.2 Public Education

Public education about transportation energy use, trends in energy use, the state's energy goals, and vehicle and fuel technologies should continue to help build support for the alternative fuel program. This measure, in combination with other "public awareness" measures, is projected to result in a reduced length of time for the new technology acceptance process. This measure includes activities described under Measures A.11, A.20, O.1, O.3, O.4, and G.3. Public awareness activities are already ongoing (for example, news media coverage of alternative fuel developments, the Honolulu Clean Cities program, etc.) and are expected to continue.

The projected impact of this measure is most significant in the near-term, with 35% more AFVs by 2004 over the "future no action" case, declining to a difference of 7% in total number of AFVs in 2014. Also, since public education and awareness is strongly tied to the effectiveness of any incentive-type measure (i.e. if the public does not know about the availability of an incentive, the public will not be influenced by the incentive), the effect of this measure increases as fuel and vehicle incentives increase.

O.3 Train Alternative Fuel and AFV Technicians

This type of program helps get dealer support for the program, and would provide colleges and technical schools with a program with a good image. The training could also include alternative fuel production, storage, and distribution facilities as well as AFVs. The most efficient approach may be to "train the trainers."

O.4 Loaner AFV Program

In a "loaner" AFV program an agency purchases typical AFVs and loans them, a few days or a week at a time, to interested members of the community. This is an effective program in arousing the interest of the community in AFVs and giving them first-hand experience.

Personnel Requirements

Each of the above measures would require personnel; staffing requirements are estimated in Table 10-15. Public outreach measures are somewhat more flexible with respect to staffing requirements than mandate or incentive programs.

Table 10-15.
Estimated Staffing Requirements for Public Outreach Measures

Measure #	Description of Measure	Staffing
O.1	Continue Dialog with Fleet Managers	0.50
O.2	Public Education	1.00
O.3	Train Alternative Fuel and AFV Technicians	0.10
O.4	Loaner AFV Program	0.10

10.3.3.6 GOVERNMENTAL ACTIVITY

The following governmental actions could be pursued.

G.1 Encourage Full Funding of EPACT and EO No. 12844

The EPACT schedules for AFV introduction are not in fact occurring because EPACT and EO 12844 have not received full funding. It is in the state's energy interest to support the full funding of EPACT and EO 12844.

G.2 Address Implementation of Act 199

Since Act 199 was enacted by the Seventeenth State Legislature and signed into law by the Governor, DBEDT must draft rules to implement an ethanol mandate (see Measure A.1.a). The draft rules should allow flexibility to refiners and the market to select (and adjust, as appropriate) the optimal use of alcohol as production costs and scales change. In addition, the availability of one type of fuel flexible vehicle (FFV) (methanol, for example) may exceed the availability of another type of FFV (ethanol, for example); this will eventually affect the overall alternative fuels picture and should be taken into consideration at the time the rules are drafted.

G.3 Maintain Effective Communications with the Legislature

Since the Legislature is quite interested in energy issues, it is essential to continue to provide it with timely, correct, complete information so that the legislation that is passed is in the best interest of Hawaii's citizens.

G.4 Work to Achieve Consensus on an Omnibus Transportation Energy Bill

Building on the environmental summit process that occurred in 1993 and 1994, the state could continue to support efforts to develop comprehensive transportation energy legislation.

G.5 Ensure Hawaii Participation in the EV "Infrastructure Working Council"

The "Infrastructure Working Council" is a broadly based group that is catalyzing consensus on EV standardization issues. Hawaii utilities, EV manufacturers, or state energy experts may be appropriate representatives of Hawaii interests.

Personnel Requirements

Each of the above measures would require some degree of staffing; staffing requirements of major measures are estimated in Table 10-16. Most measures address government activities which are already ongoing; requirements would most likely be met with existing personnel.

Table 10-16.
Estimated Staffing Requirements For Governmental Activity Measures

Measure #	Description of Measure	Staffing
G.1	Encourage Full Funding of EPACT and EO No. 12844	0.00
G.2	Implement Act 199, 1994 State Legislature	same as A.1
G.3	Maintain Effective Communication with the Legislature	0.25
G.4	Work to Achieve Consensus on an Omnibus Transportation Energy Bill	0.05
G.5	Ensure Hawaii Participation in the EV 'Infrastructure Working Council'	0.05

10.3.4 SUMMARY OF ALTERNATIVE FUEL MEASURES' EFFECTIVENESS

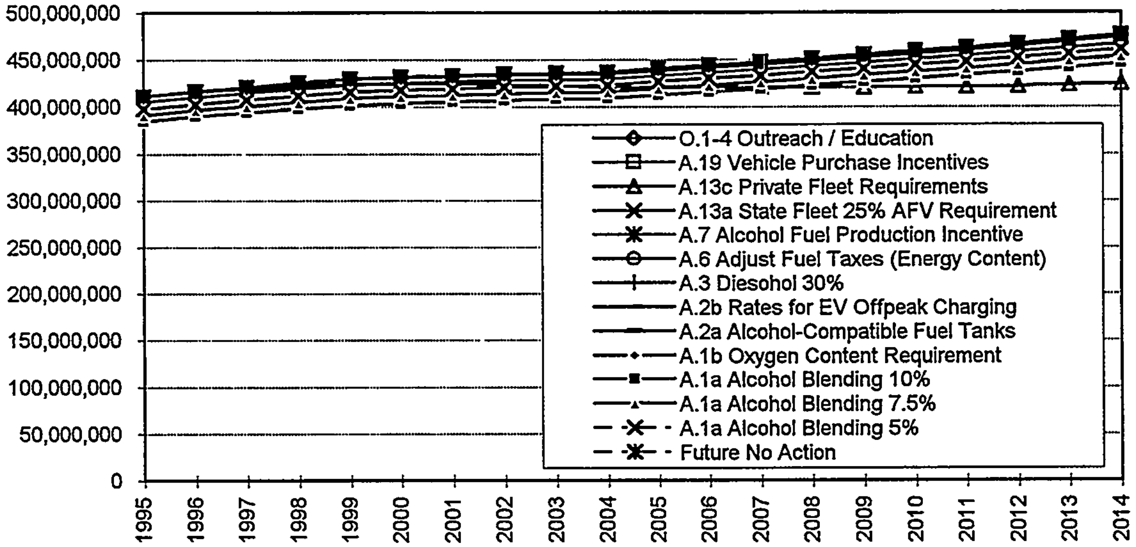
Energy, alternative fuel vehicle population, employment, and cost impacts were estimated for each of the major alternative fuel and AFV measures.

10.3.4.1 DISPLACEMENT OF GASOLINE AND DIESEL

GEG Displaced

The projected demand for gasoline and diesel fuels varies by measure, as shown in Figure 10-6 (values are more clearly presented in Table 10-18). Since the level of transportation activity and vehicle energy efficiency is held constant in for each of the measure evaluations, the reductions in demand are due to displacement of gasoline and diesel fuel by alternative fuels (i.e. the lower the demand for gasoline and diesel fuel, the higher the demand for alternative fuels). Demand is shown in terms of GEG of gasoline and diesel.

Figure 10-6.
Projected Gasoline and Diesel Demand, in GEG, 1995-2014



In all cases, projected demand for gasoline and diesel fuels in 2014 is greater than demand in 1995. Aside from measure A13c, "Private and Rental Fleets Required to Purchase AFVs," none of the measures creates more than a 10% displacement of gasoline and diesel from the "future no action" case in 2014. Even measure A13c, the measure with the greatest effect on projected gasoline and diesel demand, is not projected by itself to reduce the demand for gasoline and diesel to below 1995 levels (see Chapter 4 for a discussion of the effect of reduced rates of vehicle population increase).

Cost Per Unit of Gasoline and Diesel Displaced

Several of the measures have costs associated with their implementation. Those measures, and their associated major cost elements, are listed in Table 10-17.

Table 10-17.
Measures With Major Cost Elements

Measure		Major Cost Element
A.2.A	Alcohol or Other Oxygenate Requirement for Gasoline	State Excise Tax Exemption
A.8	Alcohol Producer Payments	Incentives Paid to Alcohol Producers
A.13.B	Fleet Purchase Requirements for State Government Fleets	AFV Purchase Price and Incremental Fuel Cost
A.13.D	Fleet Purchase Requirements for Private Fleets	AFV Purchase Price and Incremental Fuel Cost
A.20	AFV Purchase / Conversion Incentives	Incentives Paid to AFV Purchasers

Annual costs were estimated for each year between 1995 and 2014. Projected costs were distributed across the projected gasoline and diesel displacement for each year to obtain estimated cost per GEG gasoline and diesel displaced. Results are shown in Figure 10-7. **Note: potential revenue increases, added tax revenues, etc. due to increased employment or other economic activity associated with these measures was not taken into account.** The cost of program administration was also not taken into account.

Measure A13c (private fleet mandates) has the highest projected cost ($5.50 per GEG gasoline and diesel displaced in 1996). Although the fleet mandate measure requires increased AFVs purchases over the years, costs are projected to decrease due to improving technologies and reduced vehicle and fuel costs.

Measure A13a (state fleets required to purchase AFVs) shows a peak in 1998 (the first year of the requirement), with reductions in subsequent years due to improving technologies and reduced vehicle and fuel costs.

Measure A7 (payment of alcohol incentives of a level sufficient to make M85 and/or E85 competitive with gasoline at the pump) results in projected costs of approximately 50 cents to one dollar per GEG gasoline and diesel displaced over the study period. The drop in cost per GEG between the years 2000 and 2001 indicates a transition between alcohol phases. There is another (although less obvious) drop between 2011 and 2012.

The alcohol blending measures (A1a) assume that the required amounts of alcohol are used in 10% blends with gasoline, all of which would be eligible for the excise tax exemption. The cost per GEG displaced is, therefore, identical for all three blending levels. As discussed previously, an oxygenate requirement (A1b) would not involve this type of alcohol blend flexibility; therefore, measure A1b does not incur any costs relative to excise tax exemptions.

Measure A19 (vehicle purchase incentives) shows a peak in 1999 and, consistent with the incentive phase-outs used, phases out completely by 2010.

10.3.4.2 NUMBER OF ALTERNATIVE FUEL VEHICLES

As illustrated by Figure 10-8, Measure A13c is the only measure to have a significant effect on the total number of projected AFVs in use by 2014.[15]

The increased number of AFVs shown in Measure O2 (public outreach and education) illustrates an increased number of voluntary AFV purchases (as opposed to required purchases of AFVs). The other measures, by themselves, result in almost identical numbers of projected AFVs by 2014.

10.3.4.3 JOBS

Employment estimates were developed for each of the major measures; these numbers were compared using the "future no action" case as a baseline. Results are shown in Figure 10-9. Cumulative employment is indicated by columns. Projected costs were distributed across the projected cumulative number of jobs to obtain estimated cost per person-year of employment.

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[15] Most of the measures slightly affect the mix of alternative fuel vehicles more than the total number of alternative fuel vehicles.

Figure 10-7.
Cost ($) per GEG of Gasoline and Diesel Displaced, 1995-2014

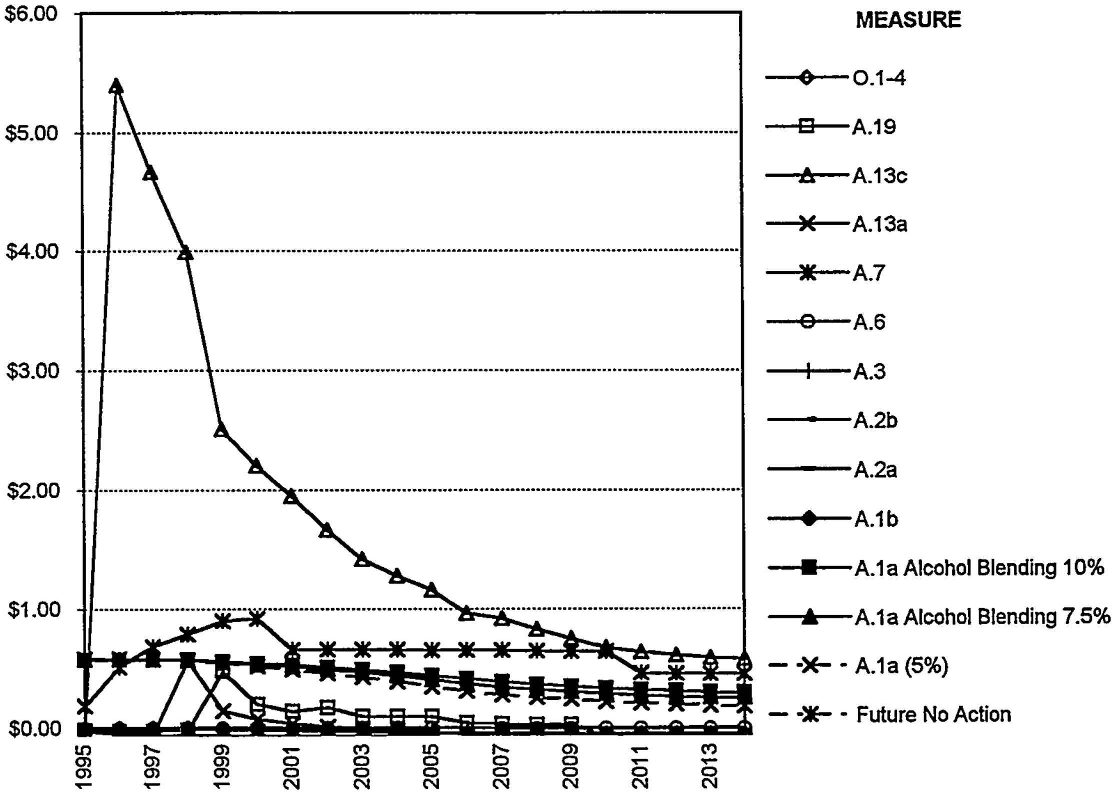


Figure 10-8.
Projected Number of Alternative Fuel Vehicles, 1995-2014

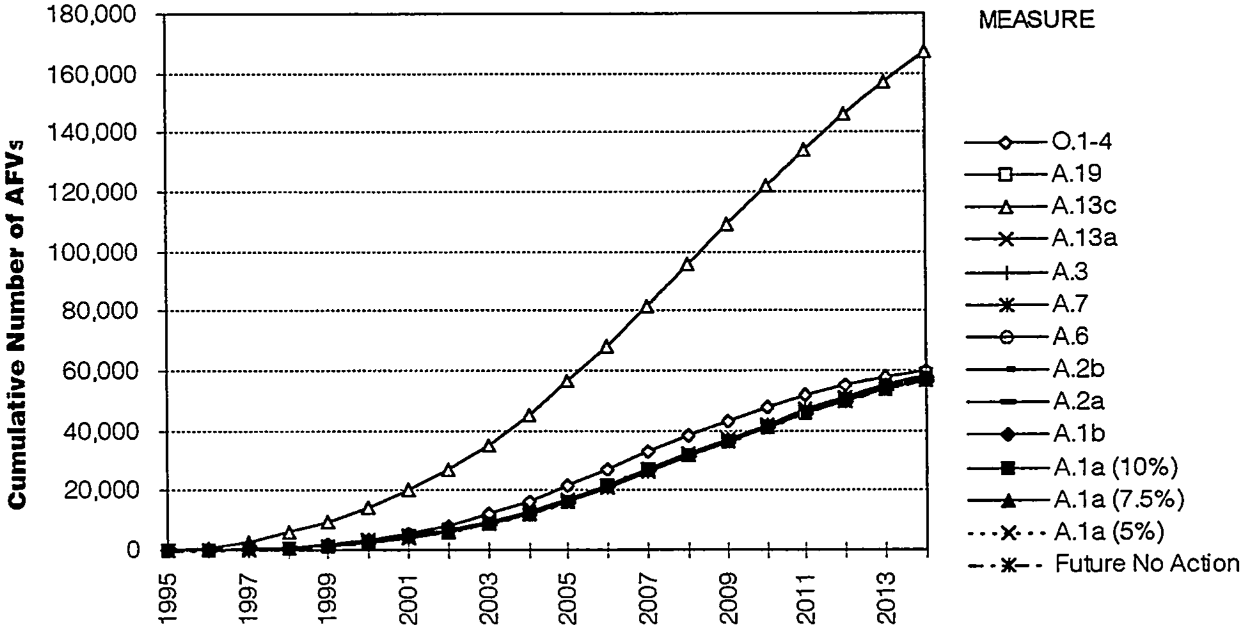
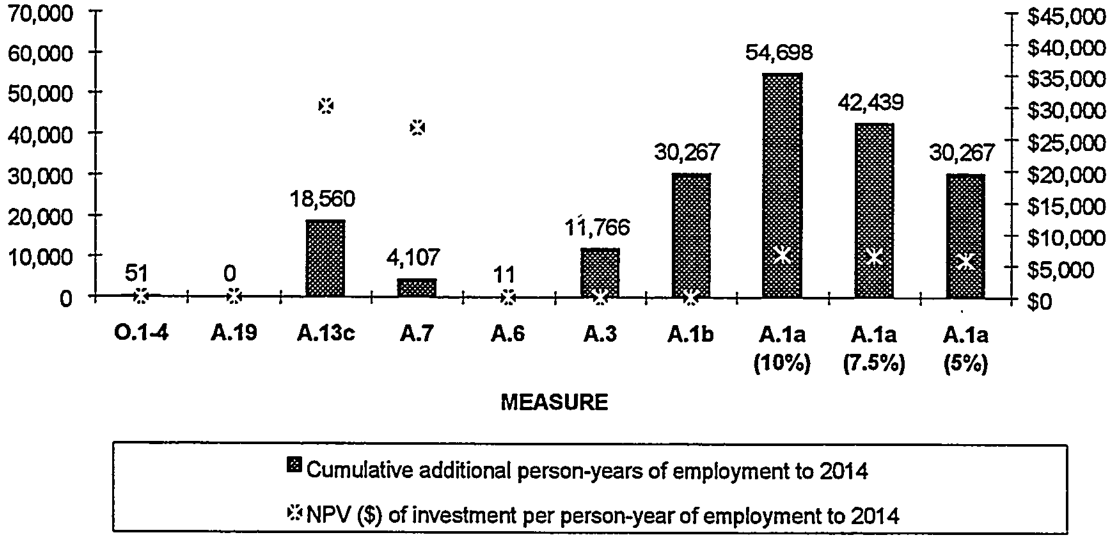


Figure 10-9.
Cumulative Employment (Person-Years, 1995-2014) And Cost Per Job



Most of the projected employment is due to local production of alcohol fuels. As described previously, the lowest cost fuel option in each phase was used for cost and employment projections. Fuel production costs were generally lowest for those options requiring the least amount of labor (and therefore providing the fewest jobs); production of alcohol fuels from agricultural crops, for example, were not projected to begin until Phase 4, when the demand for alcohol fuels exceeds 30 million GEG per year. This is apparent with measure A1a with 10% blending showing a significantly greater cumulative employment than other measures.

10.3.4.4 SUMMARY

Table 10-18 shows the projected alternative fuel demand, number of AFVs in operation, and number of jobs for most significant measures in the years 2004 and 2014. Measures are arranged in order of demand for alternative fuel in 2014.

The effectiveness of individual measures in accomplishing any one of several possible goals depends on a variety of factors. The results shown in the table above are simply one possible outcome resulting from one particular set of assumptions. As technologies, prices, and other factors change, so to will the relative effectiveness of these types of measures. The intent of this project is to provide a preliminary evaluation and to develop tools to help decision-makers evaluate the numerous options in the area of transportation energy and alternative fuels.

If the overall objectives are maximum displacement of gasoline and diesel fuel over the long term, or maximizing the number of AFVs in use, then a measure such as A13c, requiring private fleets to purchase AFVs, is projected to accomplish the greatest amount of displacement over a twenty-year timeframe (although, as previously shown, with a relatively high projected cost per GEG displaced). The next most effective single measure to maximize the number of AFVs in use is outreach / education (which is projected to increase voluntary procurement of AFVs at a minimal cost per projected GEG displaced).

Table 10-18.
Effectiveness of Individual Measures

Year	2004			2014		
Measure	Displacement of Gasoline & Diesel (Million GEG)	AFVs in Operation (Thousands)	Number of Jobs	Displacement of Gasoline & Diesel (Million GEG)	AFVs in Operation (Thousands)	Number of Jobs
A.13c Private Fleet Requirements	22	45	33	77	167	2,608
A.1a Alcohol Blending 10%	34	12	2,608	56	57	3,478
A.1a Alcohol Blending 7.5%	27	12	2,000	48	57	2,782
A.1a/A.1b Alcohol Blending 5%	20	12	1,391	41	57	2,174
A.3 Diesohol 30%	13	12	33	35	57	1,652
O.1-4 Outreach / Education	8	16	11	27	60	37
A.7 Alcohol Fuel Production Incentive	6	12	11	27	59	1,130
A.13a State Fleet 25% AFV Requirement	6	13	7	26	57	33
A.6 Adjust Fuel Taxes (Energy Content)	6	12	7	26	57	37
A.2b Rates for EV Offpeak Charging	6	12	7	26	57	33
A.2a Alcohol-Compatible Fuel Tanks	6	12	7	26	57	33
Future No Action	6	12	7	26	57	33

If the overall objective is maximum displacement of gasoline and diesel fuel over a shorter term, then the alcohol blending measures are the most effective.

If the objective is to maximize employment in an alternative fuels industry, then the measures which maximize use of alcohol fuels are the most effective.

If the objective is a cost-effective program which accomplishes several goals simultaneously, then a mix of measures may be appropriate. Groups of measures are evaluated in the next section.

10.4 COMBINATIONS OF MEASURES (POSSIBLE SCENARIOS)

Several of the measures described in the previous section are complementary to each other. For example, a measure such as alcohol blending may spur local fuel production of several million gallons per year and thus allow the lower-volume, higher-cost phases of alcohol (M85/E85) for use in AFVs to be avoided. Or, the provision of vehicle incentives may increase the attractiveness of AFVs (and therefore the demand for fuel), thereby reducing fuel costs.

Some measures may interfere with one another or increase program costs. For example, aggressive AFV measures (such as private fleet mandates) increase the number of alternative fuel vehicles and reduce the number of conventionally fueled vehicles - which reduces the amount of conventional fuel into which low levels of alcohol may be blended. Another example would be a case in which alcohol incentives were put into place with the intent of making high-level alcohol fuels cost competitive with gasoline, but those incentives were used for low-level blends (for which a much smaller incentive, if any, would have been sufficient); in such a case, large costs would have been incurred with little additional benefit.

The following section evaluates groups of measures ("scenarios") for overall effectiveness and cost.

10.4.1 MEASURES ASSOCIATED WITH ALL SCENARIOS

Several measures have been included as common elements in all scenario runs. In general, these are measures which have already occurred to some extent, are occurring or expected to occur voluntarily, or are essentially non-controversial and non-cost items. The measures included as common elements in all scenario runs are shown in Table 10-19.

Table 10-19.
Measures Included as Common Elements in All Scenario Runs

A.2.a	New or Replacement Fueling Facilities to be Alcohol-Compatible
A.2.b.2	Off-Peak Recharging for Electric Vehicles Available at a Reduced Rate
A.6	Adjust Fuel Taxes on the Basis of Energy Content
A.13.a	Fleet Purchase Requirements for State Government Fleets
O.2	Public Education / Outreach

Measure A.2.a is expected to occur voluntarily to some extent; as discussed previously, increasingly stringent underground tank requirements may result in voluntary installation of highly corrosion-proof tanks, such as double-walled stainless steel tanks, which are compatible with high level alcohol blends. Measure A.2.b.2, off-peak recharging of electric vehicles, is highly desirable from an electric utility load management point of view, and without some type of incentive and control over EV recharging times, utilities could experience increased loads at their peak load times; therefore, this measure is considered likely. Measure A.6, adjustment of fuel taxes on the basis of energy content, would remove a disincentive to alternative fuel use while maintaining funding levels for highways; therefore, this measure is considered a non-controversial, non-cost item. Measure A.13.a, State Government Fleet Purchase Requirement, has already occurred with Administrative Directive 94-06. Measure O.2 is already occurring, with public and private organizations cooperating in public education and outreach on the topic of alternative fuels and AFVs.

10.4.2 SCENARIOS

Measures were combined in nine scenarios to illustrate a range of approaches. The nine measure combinations (scenarios A through I) are described below.

A. Common Elements Only
B. Ethanol Blending (10%)
C. Ethanol Blending (10%) & Alcohol Vehicle Purchase Incentives
D. Alcohol (M85/E85) Fuel & Vehicle Purchase Incentives
E. Alcohol (M85/E85) Fuel & Vehicle Purchase Incentives & Alcohol (10%) Blending
F. Alcohol & Electric Vehicle Purchase Incentives
G. Ethanol Blending (10%) & Vehicle Incentives; Fleet Mandates Later
H. Fleet Mandates & Fuel & Vehicle Incentives
I. Everything

SCENARIO A: COMMON ELEMENTS ONLY

In this scenario, common elements only (see previous section) were included. This scenario resulted in a decrease of gasoline and diesel demand in 2014 of 0.5% compared to the "future no action" case. This scenario also resulted in an increase in total number of AFVs of 40% in 2004 and 8% in 2014 over the "future no action" case.

SCENARIO B: ETHANOL BLENDING (10%)

In this scenario, 10% ethanol blending and common elements were included. This scenario resulted in an increase in the displacement of gasoline and diesel fuel by alcohol in 2014 of 300% compared to the "future no action" case. This scenario also resulted in an increase in total number of AFVs of 41% in 2004 and 10% in 2014 over the "future no action" case.

SCENARIO C: ETHANOL BLENDING (10%) & ALCOHOL VEHICLE INCENTIVES

In this scenario, ethanol blending, alcohol vehicle incentives of $500 per vehicle (using the same phase-outs as in the individual measure evaluations of the previous section), and common elements were included. This scenario resulted in an increase in the displacement of gasoline and diesel fuel by alcohol in 2014 of 300% compared to the "future no action" case. This scenario also resulted in an increase in total number of AFVs of 41% in 2004 and 10% in 2014 over the "future no action" case.

SCENARIO D: ALCOHOL (M85/E85) FUEL & VEHICLE INCENTIVES

In this scenario, alcohol fuel incentives (payment of alcohol incentives of a level sufficient to make M85 and/or E85 competitive with gasoline at the pump), alcohol vehicle purchase incentives of $500 per vehicle (using the same phase-outs as in the individual measure evaluations of the previous section), and common elements were included. This scenario resulted in an increase in the displacement of gasoline and diesel fuel by alcohol in 2014 of 34% compared to the "future no action" case. This scenario also resulted in an increase in total number of AFVs of 43% in 2004 and 12% in 2014 over the "future no action" case.

SCENARIO E: ALCOHOL (M85/E85) FUEL & VEHICLE INCENTIVES & ETHANOL BLENDING (10%)

In this scenario, alcohol fuel incentives (payment of alcohol incentives of a level sufficient to make M85 and/or E85 competitive with gasoline at the pump), alcohol vehicle purchase incentives of $500 per vehicle (using the same phase-outs as in the individual measure evaluations of the previous section), ethanol blending, and common elements were included. This scenario resulted in an increase in the displacement of gasoline and diesel fuel by alcohol in 2014 of 320% compared to the "future no action" case. This scenario also resulted in an increase in total number of AFVs of 43% in 2004 and 12% in 2014 over the "future no action" case.

SCENARIO F: VEHICLE PURCHASE INCENTIVES

In this scenario, vehicle purchase incentives of $500 and $2000 per alcohol and electric vehicle, respectively (using the same phase-outs as in the individual measure evaluations of the previous section) and common elements were included. This scenario resulted in an increase in the displacement of gasoline and diesel fuel in 2014 of 0.5% compared to the "future no action" case. This scenario also resulted in an increase in total number of AFVs of 40% in 2004 and 9% in 2014 over the "future no action" case.

SCENARIO G: ETHANOL BLENDING (10%) & VEHICLE INCENTIVES; FLEET MANDATES LATER

In this scenario, 10% ethanol blending, vehicle purchase incentives of $500 and $2000 per alcohol and electric vehicle, respectively (using delayed phase-outs), delayed fleet mandates, and common elements were included. Fleet mandate and incentive phase-out rates used are shown in Table 10-20.

Table 10-20.
Fleet Mandate and Incentive Phase-Out Rates Used for Scenario G

Year	Rental fleets	Private (non-rental) fleets	EPACT
	percentage of new vehicles required to be AFVs:	percentage of new vehicles required to be AFVs:	requirement for non-government "covered fleets"
1995	0%	0%	0%
1999	0%	10%	20%
2003	10%	25%	40%
2007	20%	50%	70%
2009	25%	50%	70%
2011	30%	50%	70%
2015	40%	50%	70%

Phase	Period				% of original incentive
Phase 1	from	1995	to	2002	100%
Phase 2	from	2002	to	2005	75%
Phase 3	from	2005	to	2007	50%
Phase 4	from	2007	to	2009	35%
Phase 5	from	2009	on...		0%

This scenario resulted in a decrease of gasoline and diesel demand in 2014 of 14% compared to the "future no action" case. This scenario also resulted in an increase in total number of AFVs of 170% in 2004 and 140% in 2014 over the "future no action" case.

SCENARIO H: FLEET MANDATES WITH FUEL INCENTIVES & VEHICLE PURCHASE INCENTIVES

In this scenario, fleet mandates (using the same percentage requirements as in the individual measure evaluations of the previous section), alcohol fuel incentives (payment of alcohol incentives of a level sufficient to make M85 and/or E85 competitive with gasoline at the pump), vehicle purchase incentives of $500 and $2000 per alcohol and electric vehicle, respectively (using the accelerated phase-outs shown in Table 10-21), and common elements were included. The accelerated rate of incentive phase out is due to the large number of vehicles being purchased by fleets due to mandate requirements.

Table 10-21.
Incentive Phase-Out Rates Used for Scenarios H and I

Phase	Period				% of original tax credit
Phase 1	from	1995	to	1997	100%
Phase 2	from	1997	to	1999	75%
Phase 3	from	1999	to	2001	50%
Phase 4	from	2001	to	2003	35%
Phase 5	from	2003	on...		0%

This scenario resulted in a projected decrease of gasoline and diesel demand in 2014 of 11% compared to the "future no action" case. This scenario also resulted in an increase in total number of AFVs of 290% over the "future no action" case in 2004 and of 200% in 2014.

SCENARIO I: EVERYTHING

In this scenario, fleet mandates (using the same percentage requirements as in the individual measure evaluations of the previous section), alcohol fuel incentives (payment of alcohol incentives of a level sufficient to make M85 and/or E85 competitive with gasoline at the pump), vehicle purchase incentives of $500 and $2000 per alcohol and electric vehicle, respectively (using the same accelerated phase-outs as used in Scenario H), ethanol blending (10%), diesohol (30%), and common elements were included. This scenario resulted in a decrease of gasoline and diesel demand in 2014 of 19% compared to the "future no action" case. This scenario also resulted in an increase in total number of AFVs of 290% in 2004 and 200% in 2014 over the "future no action" case.

10.4.3 SUMMARY OF SCENARIOS' EFFECTIVENESS

Energy, alternative fuel vehicle population, employment, and cost impacts were estimated for each of the scenarios described in the previous section.

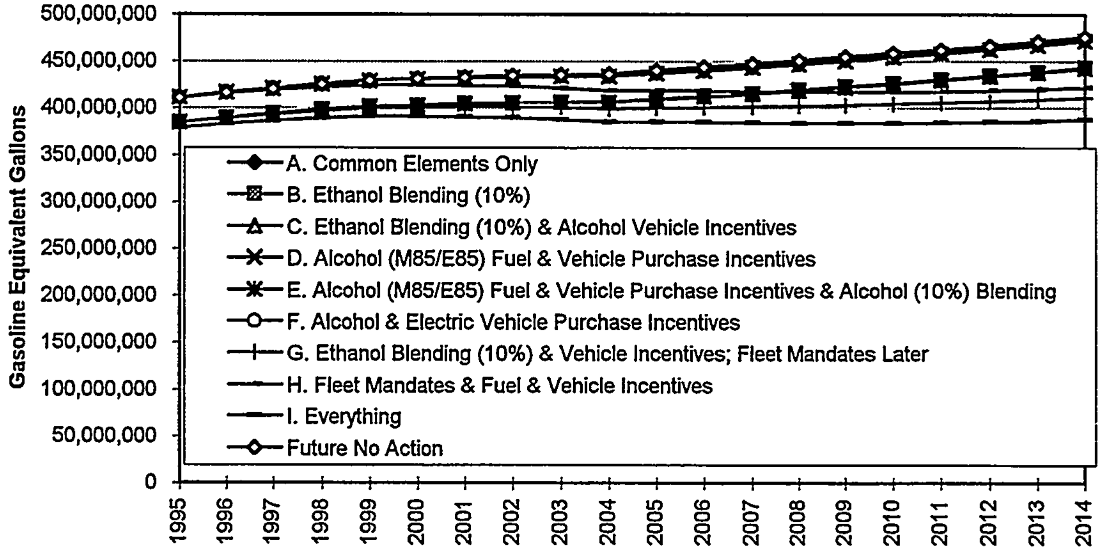
10.4.3.1 DISPLACEMENT OF GASOLINE AND DIESEL

GEG Displaced

The projected demand for gasoline and diesel fuels varies by scenario, as shown in Figure 10-10. Demand is shown in terms of GEG of gasoline and diesel.

As may be expected, the projected displacement of gasoline and diesel in 2014 is greatest for those scenarios involving fleet mandates and alcohol blending (Scenarios G and I), followed by fleet mandates without alcohol blending (Scenario H). Very similar projections of gasoline and diesel demand are obtained for Scenarios B, C, and E, indicating that the most significant element in those scenarios is the shared element of ethanol blending; likewise, similar projections are obtained for Scenarios A, D, and F, indicating that the proposed level and application of fuel and vehicle credits, even in combination, are not projected to have a significant effect on overall demand for gasoline and diesel.

Figure 10-10.
Projected Gasoline and Diesel Demand Under Various Scenarios, 1995-2014



In all cases, projected demand for gasoline and diesel fuels in 2014 is equal to or greater than demand in 1995.

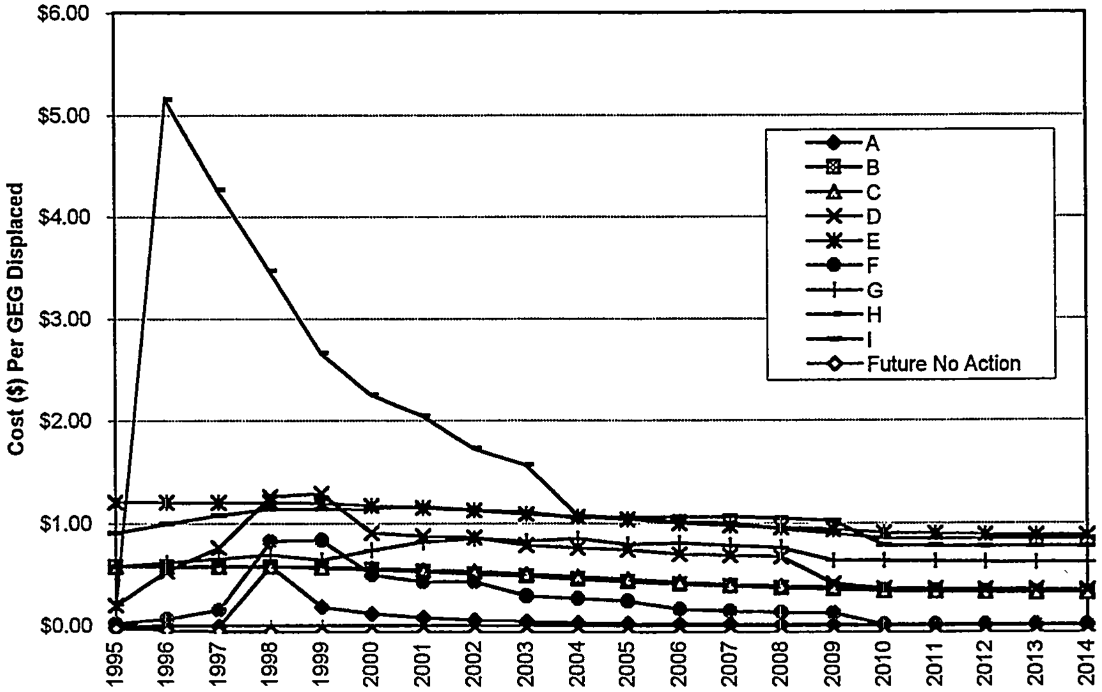
Cost Per Unit of Gasoline and Diesel Displaced

Several of the measures included in scenario runs have costs associated with their implementation. Costs for scenarios were determined for each year between 1995 and 2014. Projected costs were distributed across the projected gasoline and diesel displacement for each year to obtain estimated cost per GEG gasoline and diesel displaced. Results are shown in Figure 10-11. **Note: potential revenue increases, added tax revenues, etc. due to increased employment or other economic activity associated with these scenarios were not taken into account.** Program administration costs were not included either. These costs and benefits may be quantified and added as program direction and scope are refined.

Scenario H (fleet mandates with fuel and vehicle incentives) has the highest projected cost (over $5.00 per GEG gasoline and diesel displaced in 1996). This projected cost is lower than was projected in the previous section for fleet mandates alone because the combination of mandates and incentives increases demand for the fuels enough to slightly reduce fuel costs.

Scenarios I (everything) and **E** (alcohol fuel & vehicle incentives & ethanol blending) have costs which are lower than Scenario H, due to the combination of measures resulting in high enough demand to cause additional reductions in fuel costs. The level of displacement for Scenario I is more than twice the level of displacement of Scenario E, with similar costs ($0.82 and $0.81 in 2014, respectively).

Figure 10-11.
Cost ($) per GEG of Gasoline and Diesel Displaced Under Various Scenarios, 1995-2014



The level of displacement for **Scenario E** is similar to displacement for **Scenario C** (ethanol blending & alcohol vehicle incentives), but the cost per GEG displaced in Scenario C ($0.32 in 2014) is less than half of cost per GEG displaced in Scenario E. The difference between the two scenarios is that Scenario E includes paying alcohol fuel production incentives of a level sufficient to make M85 and/or E85 competitive with gasoline at the pump (while simultaneously using large quantities of alcohol fuels in low-level blends); Scenario C includes the ethanol blending and vehicle incentives but not the production incentives for the high level blends.

Scenario D (alcohol fuel & vehicle incentives) has a cost ($0.35 per GEG) greater than **Scenario C**, with one-tenth the level of displacement. **Scenario B** had costs ($0.32 per

GEG in 2014) and displacements almost identical to Scenario C. Scenarios B and C had the fifth highest level of displacement and third lowest cost per GEG displaced.

This wide variation in costs and results in scenarios targeting alcohol fuels illustrates the importance of providing cost-effective incentives which are necessary (don't pay more than is necessary) and sufficient (don't pay less than is sufficient). If low-level blends are in use, paying producer incentives geared towards high level blends is more than is necessary. If low-level blends are not in use, vehicle and fuel incentives alone are not sufficient to accomplish a significant level of displacement.

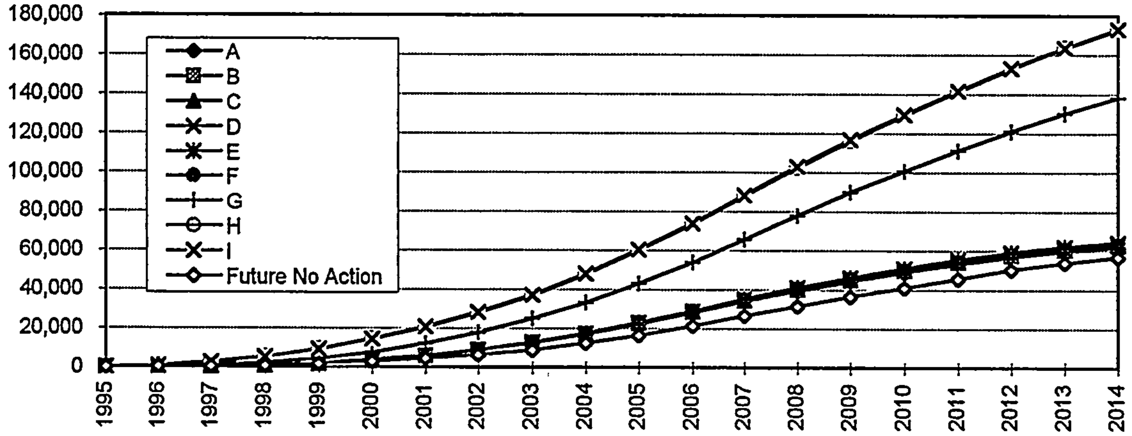
Scenario G (ethanol blending & vehicle incentives; fleet mandates later) starts with ethanol blending and phases in fleet mandates later, when fuel and vehicle costs have been reduced. This scenario has the second highest level of displacement and sixth lowest cost per GEG displaced. Costs of this scenario could be reduced if vehicle incentives were reduced or phased out at a faster rate.

Scenario F, vehicle incentives only, resulted in even less displacement than Scenario D, but at no cost in 2014 since the incentives are phased out. This approach, although without the levels of displacement of the other scenarios, is relatively low-cost and low-risk. **Scenario A**, common elements only, resulted in the lowest levels of displacement, with the lowest costs. This approach, although without the levels of displacement of the other scenarios, is the lowest-cost and lowest-risk.

10.4.3.2 NUMBER OF ALTERNATIVE FUEL VEHICLES

As illustrated by Figure 10-12, the scenarios with fleet mandates (Scenarios G, H and I) are projected to have significantly more AFVs in use by 2014.

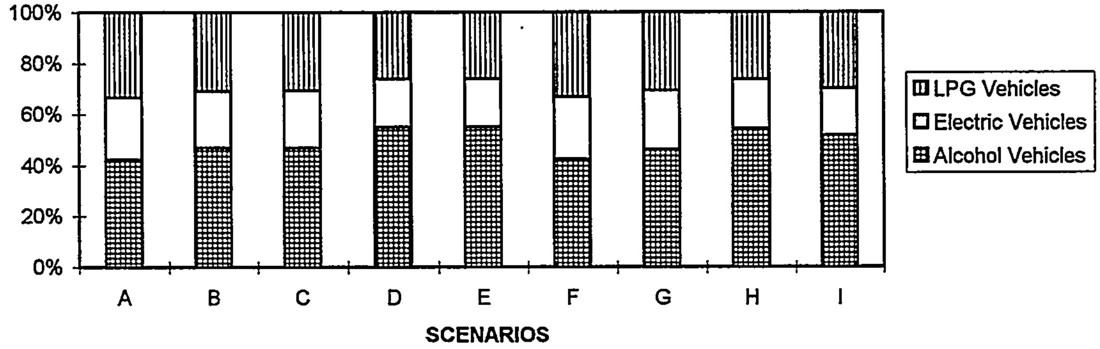
Figure 10-12.
Projected Number of Alternative Fuel Vehicles Under Various Scenarios, 1995-2014



Even without fleet mandates, several thousand (about 60,000) AFVs are projected to be in use by 2014. The difference in total number of vehicles between the various scenarios and the "future no action" case is due to increased voluntary purchases of alternative fuel vehicles (primarily due to public outreach efforts).

The total number of AFVs projected under scenarios A through F remain fairly constant, in spite of different combinations of fuel and vehicle incentives. The overall effect of the modeled incentives was to influence the mix of alternative fuel vehicles, as illustrated by Figure 10-13, rather than to increase the total number of alternative fuel vehicles. These results are very sensitive to availability of alternative fuel vehicles from the manufacturers.

Figure 10-13.
Estimated Mix of Alternative Fuel Vehicles Under Various Scenarios, 2014



10.4.3.3 JOBS

The employment potential of each of the various scenarios was estimated; as in the measure evaluations, the majority of the projected jobs occur when the demand for alcohol fuels becomes greater than 30 million gasoline equivalent gallons per year. Results are shown in Figure 10-14.

The discontinuities ("steps") in number of jobs occur at alcohol production phase transitions. For example, Scenario I (the "do everything" case) shows two discontinuities: a large increase in employment in 1997, which corresponds to a transition from alcohol production phase 3 to phase 4, and a large decrease in employment in 2012, which corresponds to a transition from alcohol production phase 4 to phase 5 (cost estimates for phase 5 have methanol produced from coal as the lowest-cost alcohol fuel option under stated assumptions).

Projected cost per unit of employment for each of the scenarios was obtained by dividing projected cumulative costs in constant dollars (cost elements are discussed in the previous section) by potential cumulative person-years of employment between 1995 and 2014. Results are shown in Figure 10-15.

As illustrated by the columns representing employment, potential employment under an alternative transportation fuels program varies considerably from one scenario to another. Cost per job also varies considerably; the lowest cost per job occurs with Scenario A, but the total number of jobs is very small as well. Scenarios B and C show potential for over 50,000 cumulative person-years of employment between 1995 and 2014, at a projected cost of less than $7,000 each, based on existing taxes, technologies, and mid-range of costs.

Figure 10-14.
Potential Employment Under Various Scenarios, 1995-2014

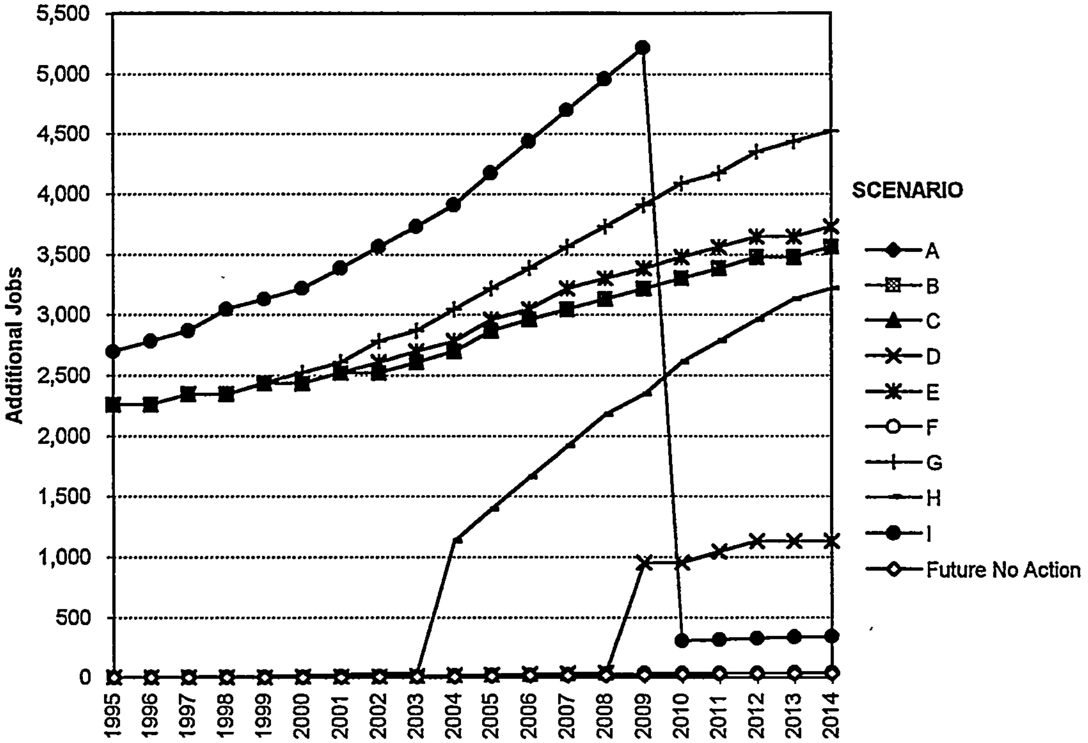
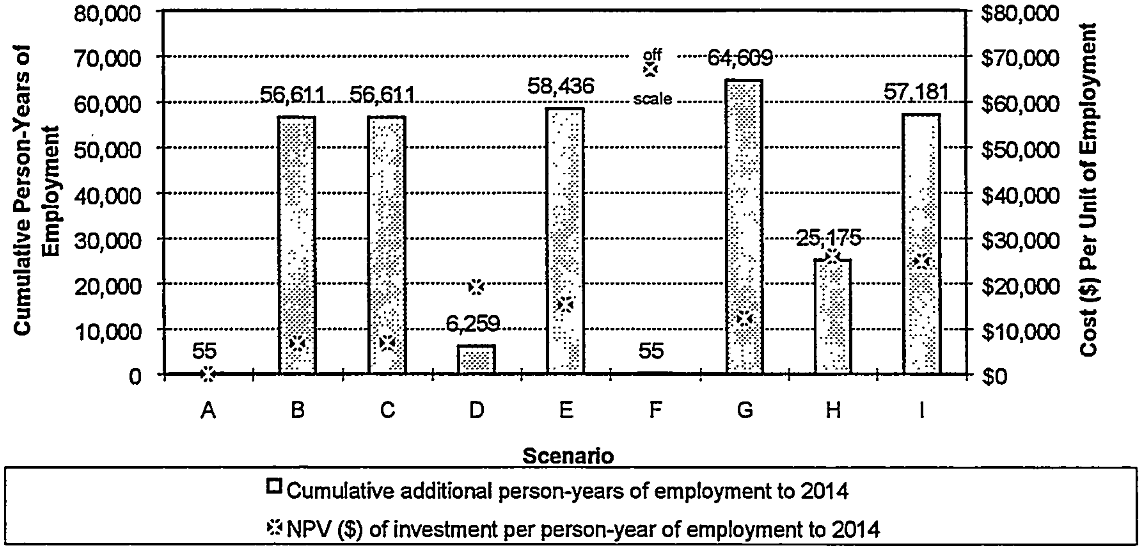


Figure 10-15.
Cumulative Employment (Person-Years, 1995-2014) and Cost Per Job



10.4.3.4 SUMMARY

Table 10-22 shows the projected alternative fuel demand, number of AFVs in operation, and number of jobs for each scenario in the years 2004 and 2014. Scenarios are arranged in order of identification letter (A-I).

If the overall objectives are maximum displacement of gasoline and diesel fuel, or maximizing the number of AFVs in use, then scenarios G and I are projected to accomplish the greatest amount of displacement both immediately and over a twenty-year timeframe (although, as previously shown, with a relatively high projected cost per GEG displaced).

If the objective is the lowest cost per GEG of gasoline and diesel displaced, than scenario A is preferable, although the magnitude of displacement is less than other scenarios. If the objective is maximum potential employment, cumulative over a twenty year timeframe, then Scenario I is preferred. If the objective is significant employment potential at the lowest cost, then Scenario B is preferred.

If a combination of objectives are to be met, then Scenario G, which provides the second highest level of gasoline and diesel fuel displacement and second highest level of employment with the fourth highest cost per GEG displaced and sixth highest cost per person-year of employment, may be the preferred option.

The scenarios evaluated are merely a sample of possible approaches. As costs, technologies, and resource constraints change, the tools developed for this project may be updated and used to evaluate the new situation.

Table 10-22.
Effectiveness of Various Scenarios

Year / Measure	2004 Displacement of Gasoline & Diesel (Million GEG)	2004 AFVs in Operation (Thousands)	2004 Number of Jobs (in 2004)	2014 Displacement of Gasoline & Diesel (Million GEG)	2014 AFVs in Operation (Thousands)	2014 Number of Jobs (in 2014)
A. Common Elements Only	2	17	11	2	62	37
B. Ethanol Blending (10%)	30	17	2,695	32	63	3,565
C. Ethanol Blending (10%) & Alcohol Vehicle Purchase Incentives	30	17	2,695	32	63	3,565
D. Alcohol (M85/E85) Fuel & Vehicle Purchase Incentives	3	17	18	4	64	1,130
E. Alcohol (M85/E85) Fuel & Vehicle Purchase Incentives & Alcohol (10%) Blending	30	17	2,782	33	64	3,738
F. Alcohol & Electric Vehicle Purchase Incentives	2	17	11	2	62	37
G. Ethanol Blending (10%) & Vehicle Incentives; Fleet Mandates Later	37	33	3,043	65	138	4,521
H. Fleet Mandates & Fuel & Vehicle Incentives	18	47	1,130	54	173	3,217
I. Everything	51	48	3,912	88	173	339
Future No Action	0	12	7	0	57	33

CHAPTER 11

RECOMMENDATIONS

11.1 INTRODUCTION

The purpose of this chapter is to draw on the work previously presented (projections of transportation activity and technology, pricing, state energy goals, and the benefits of petroleum displacement) and recommend an action plan to influence energy use in the transportation sector for state consideration. This action plan takes into consideration resource and personnel constraints.

Possible action items are divided into four basic categories: conservation; alternative fuels; research and development; and monitoring programs. Each of these categories are discussed in turn.

11.2 ENERGY CONSERVATION

11.2.1 CONSERVATION MEASURES

Potential measures to encourage transportation energy conservation are listed in Table 11-1. Energy conservation has a large potential to decrease the absolute amount of energy that would be required in comparison to a future without conservation measures.

Table 11-1
Potential Hawaii Transportation Energy Conservation Measures

Type of Measure	Description
Conservation Measures (C)	C.1 Fleet efficiency improvements C.2 Public transit improvement and expansion C.3 Transportation management associations C.4 Actions by educational institutions C.5 High-Occupancy Vehicle (HOV) facilities C.6 Automobile use disincentives C.7 Increase the focus on energy in the transportation planning process C.8 Increase the focus on energy in the land use planning process

C.1 FLEET EFFICIENCY IMPROVEMENTS

As Chapter 2 demonstrated, vehicle efficiency has a powerful effect on total ground sector energy demand. Using large enough assumptions of efficiency improvements, projected demands can decrease even while transportation activity increases. The technology for significant increases in fuel efficiency is available. Cars that average more than 50 miles per gallon are in showrooms today, and prototypes that can run 70-120 miles on a gallon of gasoline are already developed. A recent study by the American Council for an Energy Efficient Economy shows that average new car fuel economy could be improved from 28.3 to 46.5 miles per gallon without changing safety, performance, interior space, or amenities. This study further concluded that efficiency improvements could be implemented at an additional cost of less than $200 per vehicle (California Energy Commission, 1992). The recently-announced Advanced Car Initiative is a program to develop a car of the future with much higher energy efficiency than current models. Defense conversion efforts (including the use of government laboratories) are also being focused on improving vehicle efficiency through research.

If Hawaii were to adopt fuel efficiency standards more stringent than the national corporate average fuel economy (CAFE) standards, demand for transportation fuels of all types could be reduced. Alternatively, if the fuel efficiency standard exempted alternative fuel vehicles or gave them "credit" for the percentage of non-petroleum fuels used, the fuel efficiency standard could be used to increase demand for alternative fuels while decreasing the demand for petroleum fuels.

However, since the current CAFE law restricts states' abilities to act on fuel economy, it may require Congressional action to enable Hawaii to put more stringent fuel economy standards into place.

In spite of federal preemption of state authority in the area of vehicle fuel efficiency, the California Legislature has been examining a program called "Drive +" which would increase California's sales tax on vehicles having higher than average emissions and fuel use, and decrease the tax on vehicles below these averages. The program is intended to be "revenue neutral," that is, tax increases would offset tax rebates. Depending on details of the tax structure, such a program could influence consumer choices and result in an increase in average fleet efficiency. The tax schedule as well as legal, regulatory, financial and consumer choice attitudes and other implementation issues would need to be studied.

In the meantime, the government could set an example by improving the efficiency of its fleets. For example, a fleet rule could be established that would require the procurement of vehicles that are 2.5 mpg more efficient than the current CAFE standard, and this program could phase in at some future point for both county and state vehicles. While not saving that much energy, such a program would set an example, and introduce a larger number of people to higher efficiency vehicles.

C.2-6 TRAVEL REDUCTION MEASURES

As was shown in Chapter 3, anything that would decrease regional vehicle miles of travel (VMT) would help save energy. Chapter 3 reviewed 28 measures and concluded that those measures with the greatest potential to decrease regional VMT in Hawaii, and particularly Oahu, were:

- transit programs;
- transportation management associations;

- actions by educational institutions;
- high-occupancy vehicle (HOV) facilities and meaningful enforcement;
- automobile use limitations (such as road pricing); and
- land use planning.

Several of these measures are already under active study by transportation planning agencies, and the most effective way to reinforce the energy perspective in these ongoing studies is through the existing transportation planning process (Measure G.4).

Since single-occupant vehicle (SOV) disincentives are unpopular, the need to combine them with measures that enhance the attractiveness of HOVs is often discussed. Prior U.S. policies have emphasized HOV attractiveness. With important exceptions, SOV disincentives have generally been avoided.

The situation involving SOV disincentives is changing, however. For example:

- Los Angeles is showing the nation what is involved in implementing severe SOV disincentives. Under regulatory hammers contained in Title III of the Clean Air Act Amendments (CAAA) of 1990, the South Coast Air Quality Management District requires that employers of more than 100 employees develop ridesharing programs.
- Under the Integrated Surface Transportation Efficiency Act (ISTEA), funds are available to demonstrate programs such as road pricing. In 1993, there was some local interest in obtaining money for such a grant, but consensus could not be obtained and the application was not pursued. Federal policy is likely to continue to encourage pilot studies of the more severe SOV disincentives.

In addition, articles are now being published, such as Pucher's and Hirshman's The Path to Balanced Transportation (1993) state that making HOVs more attractive are not enough to produce substantial modal shifts without making SOV disincentives more stringent. It remains to be seen whether communities actually adopt stronger SOV disincentives without having to be prodded by environmental or other requirements, such as the Clean Air Act (CAA). The provisions of the CAA do not require SOV disincentives in Hawaii at this point.

In summary, conservation measures, particularly measures to increase average vehicle fuel efficiency, could provide major benefits for the state's energy use, and the next steps involved in implementing such measures should be pursued (see Measures R.1 and R.2 described later).

C.7 INCREASE THE FOCUS ON ENERGY IN THE TRANSPORTATION PLANNING PROCESS

Energy use currently receives little attention in the state's transportation planning process. There is statutory authority for energy concerns to play a much larger role. For example, ISTEA has energy efficiency as a goal[1] and the Clean Air Act Amendments of 1990 support

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[1] From the first two paragraphs of ISTEA:

energy efficient strategies. The Western Interstate Energy Board's 1993 publication, A Road Less Traveled: New Opportunities for Changing Energy Use In Transportation, spells out the opportunities to become involved in transportation planning in more detail.

More specifically, a greater focus on energy usage would favor those measures most likely to produce a significant decrease in regional VMT. A transportation project's impacts on regional VMT should be disclosed, and used as a screen to determine each project's relative impact on energy use.

It would be helpful to update and maintain ground sector energy demand projections as VMT projections are updated to show the energy consequences of transportation policy decisions and updates to the State Transportation Improvement Plan (STIP).

C.8 INCREASE THE FOCUS ON ENERGY IN THE LAND USE PLANNING PROCESS

Similarly, land use planning at the state and local levels has not placed much emphasis on transportation energy use. Land use patterns can, over time, have a powerful effect on transportation energy use (see Chapter 3), and an increased emphasis on transportation energy use during the land use planning process (e.g., revisions to Development Plans) would help achieve state goals.

11.2.2 THE NEAR TERM PROGRAM

Measures C2, C3, and C4 could provide immediate energy savings with minimum investments of time and funding. Measures C2 and C5 require equipment purchases and/or construction. Measure C1, although potentially significant, has a somewhat lower probability of success given current vehicle purchase preferences and legal barriers. Although there are no immediate savings, Measures C7 and C8 have the greatest projected long-term energy conservation potential.

The near-term program should focus on improvements to public transportation, the organization of transportation management associations and actions by education institutions. These measures provide immediate energy savings with minimum investments in time and funding.

In the near-term, transportation planning and land use planning should begin to focus more on energy issues. Although immediate savings would not be evident, planning processes offer the greatest future impacts for energy savings.

"It is the policy of the United States to develop a National Intermodal Transportation System that is economically efficient and environmentally sound, provides the foundation of the Nation to complete in the global economy, and will move people and goods in an energy efficient manner.

The National Transportation System shall consist of all forms of transportation in a unified, interconnected manner, including the transportation systems of the future, to reduce energy consumption and air pollution while promoting economic development and supporting the Nations' preeminent position in international commerce."

ISTEA also has 15 factors to be considered in the transportation planning process, the second being "The consistency of transportation planning with applicable Federal, state, and local energy conservation programs, goals, and objectives."

11.2.3 FUTURE CONSIDERATIONS

Measures C7 and C8 have the greatest projected long-term energy conservation potential.

11.2.4 STAFFING

Each of the above conservation measures would require staffing. Estimated staffing requirements are shown in Table 11-2. Since most transportation planning and public transit functions are staffed to handle a variety of assignments, the "additional staffing" shown below is intended to indicate staff resources needed in addition to those already planned or existing.

Table 11-2.
Estimated Additional Staffing Requirements for Conservation Measures

Measure #	Description of Measure	Staffing
C.1	Fleet efficiency improvements	0.20
C.2	Public Transit	0.00
C.3	Transportation management associations	0.10
C.4	Actions by educational institutions	1.00
C.5	High-Occupancy Vehicle (HOV) facilities	0.20
C.6	Automobile use disincentives	1.00
C.7	Energy Impact considerations in the Transportation Planning Process	0.50
C.8	Increase the Focus in the Land Use Planning Process	0.10

11.3 ALTERNATIVE FUELS AND VEHICLES

There are already several hundred alternative fuel vehicles in use in Hawaii. Continued and expanded use of alternative fuels and vehicles is expected to occur in response to Federal and state requirements, public support of "clean fuels," and increasing availability of alternative fuel options on popular models of cars and trucks.

The development of a local alternative fuels and vehicle industry could provide local jobs. With respect to fuel production, alcohol fuel production from agricultural materials has the highest employment potential, although costs must be evaluated on a site-specific basis. Conversion and maintenance of alternative vehicles also offers employment potential.

The analytical tools developed in this project may be used in the design of alternative transportation fuel programs which are cost-effective in realizing state goals and objectives.

11.3.1 THE NEAR TERM PROGRAM: 1995 - 2002

As discussed in Chapter 4, near-term options for alternative fuel use in the air and marine transportation sectors are extremely limited (ethanol for use in some small planes; possible use of biodiesel in as a diesel substitute in marine applications). The near-term program recommendations, therefore, focus on the ground transportation sector only.

The results of qualitative and quantitative evaluations of over twenty potential measures and nine potential scenarios (i.e. groups of measures) for increasing use of alternative transportation fuels in the ground transportation sector were presented in Chapter 10.

11.3.1.1 LOWEST-COST, LOWEST-RISK MEASURES

Several measures were identified as being non-controversial and non-cost items. Those measures, presented in Table 11-3, are recommended as the first steps in a near-term program. Measure A.2.b.2, off-peak recharging of electric vehicles, is highly desirable from an electric utility load management point of view, since without some type of incentive and control over EV recharging times, utilities could experience increased loads at their peak load times. Measure A.6, adjustment of fuel taxes on the basis of energy content, would remove a disincentive to alternative fuel use while maintaining funding levels for highways. Measure O.2, essential for public acceptance and voluntary purchases of alternative fuel vehicles (AFVs), is already occurring.

Table 11-3.
Recommended First Steps in a Near-Term Alternative Fuels Program

A.2.b.2	Off-Peak Recharging for Electric Vehicles Available at a Reduced Rate
A.6	Adjust Fuel Taxes on the Basis of Energy Content
O.2	Public Education / Outreach

11.3.1.2 ALCOHOL / GASOLINE BLENDS

Of the potential alternative transportation fuel measures and scenarios evaluated in Chapter 10, an alcohol/gasoline blend program was the most cost-effective means of encouraging the use of significant quantities of renewable, locally-produced alternative fuels.

There are several reasons to focus on alcohol in gasoline before focusing on increasing use of alcohol fuels in fleets.

For example:

- A 10% alcohol blend in 50% of the gasolines in the state would require approximately 19 million gallons of alcohol. The number of E85 cars that would be required to create a demand for 19 million gallons of ethanol (or M85 cars for methanol) would be about 35,000 vehicles. Although there are some complexities to be dealt with in a large alcohol blending program, those issues are much less complex than the issues that would be involved in getting 35,000 alcohol-fueled vehicles into use, especially without any locally-available fuel.

- The alcohol cost analyses in Chapter 8 indicated that low-level alcohol blends (E10) are much closer to being competitively-priced than the higher level alcohol (M85 and E85) fuels.

- The projected amount of subsidy needed for M85 and E85 fuels to compete with current gasoline prices would be even higher without the economy of scale provided by an ethanol blending program.

Therefore, a gradual introduction of alcohol/gasoline blends into the marketplace, combined with public outreach and provision of knowledgeable answers to questions from motorists, is recommended.

The objective of alcohol blending would be to have the alcohol (most likely ethanol) produced locally. Consideration should be given to replacing the existing excise tax exemption for ethanol blends by a producer incentive available only to in-state alternative fuel producers. (Analytical tools developed for this project may be helpful in comparing options).

Prior to moving forward with an alcohol/gasoline blending program, the statewide economic impacts of the specific projected levels of alcohol production should be determined (including effects of avoiding economic dislocations and value of investment and construction jobs). Incentives should be based on the extent to which the activities made possible by such incentives provide tangible benefits to Hawaii's economy and energy situation which would otherwise not be available.

11.3.1.3 ESTIMATED TIMEFRAME FOR NEAR - TERM PROGRAM

The lowest-cost, lowest-risk measures could begin to be implemented immediately. Off-peak rates could be proposed by the electric utilities to the Public Utilities Commission. A fuel tax adjustment on the basis of energy content could be introduced in the next Legislative session. Programs such as "Honolulu Clean Cities" and alternative fuel vehicle demonstrations could continue.

The first alcohol production facilities may be expected to take at least three years to come on-line, and it is unlikely that the first facilities would produce 40 million gallons all at once.[2] A seven-year phase-in period would be a reasonable assumption;[3] thus, the estimated 1995-2002 timeframe.

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[2] Chapters 7 and 8 provide information on potential feedstock quantities and availability, which are important factors in determining cost-effective facility sizes.

[3] Actual program structure would be determined through a rulemaking process, during which all interested and affected parties would have an opportunity to discuss timing and other implementation issues.

11.3.2. THE MID-TERM PROGRAM: 2003 - 2014

A mid-term program would commence once the near-term program had reached its maximum effectiveness. By that time, if Energy Policy Act (EPACT) requirements, public outreach and fuel and vehicle availability have been consistent throughout the previous period, it is estimated that over 10,000 alternative fuel vehicles may be in use in Hawaii.

At that time it would be appropriate to re-evaluate the cost, availability, and desirability of the various alternative fuel vehicles and incentives. Both alternative fuels and alternative fuel vehicles are expected to be more cost-effective as well as widely available in popular models of cars, trucks, and heavy-duty vehicles. Hydrogen and fuel cell vehicles may have progressed to commercial availability. There may also be more information on possible use of alternative fuels in the air and marine sectors.

Vehicle purchase incentives and fuel incentives may be appropriate, as may fleet incentives and mandates. Success in this phase will depend on a reassessment of the technologies to be encouraged.

Abandonment of an alcohol vehicle program may be necessary at this point if manufacturers do not supply large numbers of diverse models of alcohol vehicles. The manufacturers' decisions are beyond Hawaii's control.[4] However, program risk to this point will have been small because the local alcohol production will still be small enough to be absorbed by the gasoline blend component of the strategy, and alcohol flexible-fuel vehicles (FFVs) could be operated on low-level blends if high-level alcohol blends appear uneconomic.

An expanded alcohol program, however, may be desired. Success for an alcohol strategy would depend on a well-coordinated plan to get through the transition quickly, to minimize excess costs, and on the continued supply of alcohol vehicles. The program may need to focus on one alcohol to avoid duplication of fuel storage and distribution systems and simplify public education and support. If fuel costs are still higher than for gasoline and diesel, one method of reducing the price at the pump for high level blends (without interfering with low-level ethanol blends) would be to reduce or eliminate state and county highway taxes on alternative fuels. This could be a temporary reduction, to be phased back in before the number of alternative fuel vehicles getting a "free ride" on the highways became too burdensome.

Electric vehicles may also be widely available (California's requirement for 2003 is that 10% of new light-duty vehicle sales are to be zero emission vehicles). Public interest and support of electric vehicles may create support for infrastructure development (quick-charge and opportunity charging locations), including charging at public facilities (on-street parking, schools, scenic points).

If information on vehicle preferences has been obtained prior to this point, such information could form the basis for a new assessment of the most effective measures to encourage continued and increased use of alternative fuel vehicles.

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[4] It would be affected by national considerations of EPACT evolution, Corporate Average Fuel Economy Standards and mainland air quality programs.

11.3.3 THE MATURING PROGRAM

In the mature program, alternative fuels would have achieved cost-effective scales of production and distribution, and government subsidies and incentives would be phased out.

11.3.4 ESTIMATED EFFECTIVENESS OF RECOMMENDED PROGRAM

Future fuel demand and number of alternative fuel vehicles were estimated for a near-term program (with recommended measures and a seven-year phasing in of alcohol blending in gasoline) followed by a mid-term program with increased fleet use of alternative fuel vehicles. Results are shown in Figures 11-1 and 11-2.

Figure 11-1.
Estimated Gasoline and Diesel Demand, Recommended Program

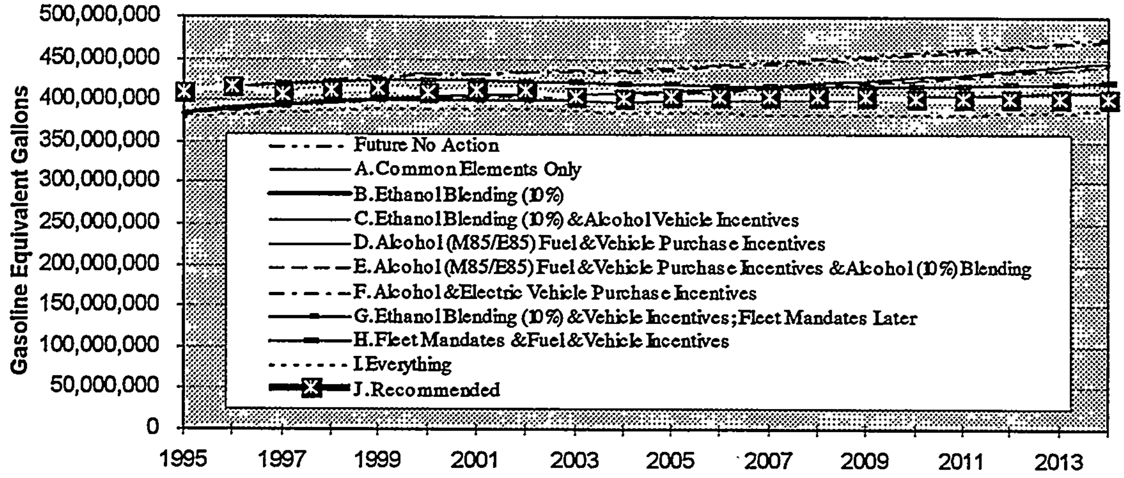
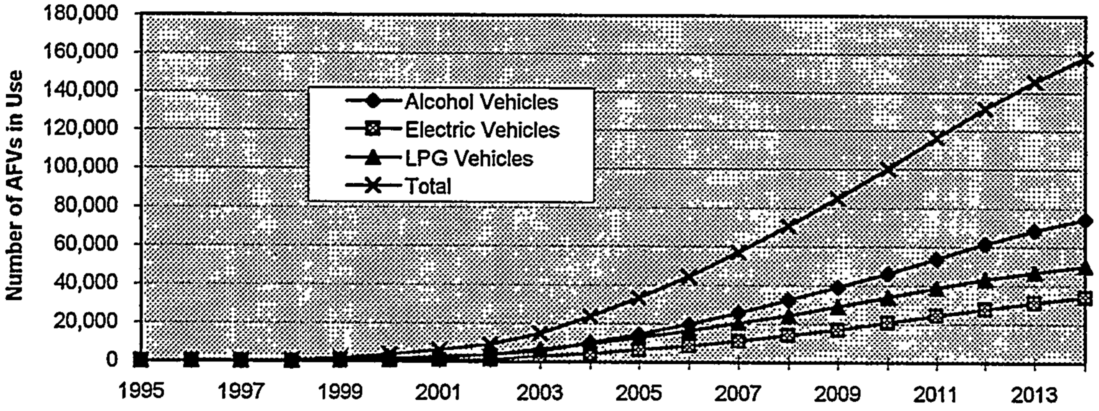


Figure 11-2.
Projected Number of Alternative Fuel Vehicles, Recommended Program



As shown, the recommended gradual phasing in of alcohol-blended fuels, followed by increased focus on alternative fuel vehicles in fleets, results in a projection of gradually increasing displacement of gasoline and diesel fuel (with absolute demand for gasoline and diesel fuel remaining relatively constant). As discussed previously, this is only one of several possible approaches. Depending on resources and support, a more or less aggressive approach may be warranted.

11.3.5 STAFFING

The alternative fuel program would require additional staffing. Estimated staffing requirements for near-term measures are shown in Table 11-4.

Table 11-4.
Minimum Staffing Requirements Associated With Near-Term Alternative Fuel Measures

Measure #	Description of Measure	Initial	Ongoing
A.1	Alcohol or Other Oxygenate Requirement for Gasoline	1.00	0.25
A.2.B.2	Off-Peak Recharging for Electric Vehicles Available at a Reduced Rate	0.05	0.00
A.6	Adjust Other Fuel Taxes on the Basis of Energy Content	0.10	0.00
0.1 - 0.4	Public Education & Outreach; Information Dissemination	1.70	1.70
	TOTAL	**2.85**	**1.95**

It should be expected that the speed and ease of implementation of these measures, as well as overall program effectiveness, will be directly related to the level (quality and quantity) of personnel assigned to implement the various measures. If personnel are not available to meet the minimum staffing requirements listed above, it is recommended that implementation be delayed until sufficient personnel are available.

11.4 RESEARCH AND DEVELOPMENT

11.4.1 RESEARCH AND DEVELOPMENT PROGRAMS

Research and development programs could play an important part in Hawaii's achievement of its energy goals. Potential areas of research and development are listed in Table 11-5.

Building partly on measures described in other sections, the following research and development programs could be pursued as part of an integrated approach. While topics in both tiers are viewed as important, the first tier topics may be more immediate than the second tier topics.

FIRST TIER TOPICS

R.1 Regulatory Analysis, Legal Review and Consumer Study on Increasing In-State Fuel Efficiency

This study is directly related to Measure C1. Such a study would address such issues as:

- What level of fees would effect consumer choice in selecting an efficient vehicle?;
- At what point to impose the fees (e.g. as a sales tax or as an annual registration fee)?;

- How would this revenue neutral fund operate? One option would be to not specify the amount of the rebate until revenues for the fiscal year are known, then apportion rebates on a formula basis. However, this would dilute the effect of the rebate since prospective purchasers would not know the rebate amount at the time of purchase;
- Would the fee apply only to new car sales or also used car sales?

While the feebate could be based on energy efficiency, it could also be based on emission levels.

Another possible way to increase fleet efficiency is to subsidize the scrapping of older, low efficiency vehicles. UNOCAL sponsored a program in California where, in order to obtain air quality increments for its own development, it funded the purchase of higher polluting, pre-1973 vehicles. This type of program appears to be most cost-effective for areas which (unlike

Table 11-5.
Potential Hawaii Research and Development Programs

Type of Measure		Description
Research and Development Programs (R)		**First Tier**
	R.1	Feasibility study on increasing in-state vehicle fuel efficiency
	R.2	Further Study of Measures to Decrease Regional VMT
	R.3	Fleet rules
	R.4	Study of Hawaii-specific barriers to alternative fuels
	R.5	Continued support and expansion of demonstration programs
	R.6	Monitoring of demonstration programs on the mainland
	R.7	Maintaining dialogue with manufacturers on state interest in ethanol FFVs
	R.8	Updating and refining alternative fuel cost estimates
		Second Tier
	R.9	Study of incentives for AFVs
	R.10	Monitoring manufacturer offerings and consumer acceptance
	R.11	Evaluation of biodiesel compatibility with existing infrastructure
	R.12	Study further state backing of industrial development bonds
	R.13	Monitor progress in reducing the technical barriers
	R.14	Monitor research using MSW and other wastes to make alcohol
	R.15	Evaluate primary and secondary economic impacts of a local fuels production industry
	R.16	Further evaluation of cost and logistics of transport of alternative fuels between islands and between terminal facilities
	R.17	Survey of Hawaii-specific vehicle purchase preferences
	R.18	Survey of fleets
	R.19	Fund other research as appropriate and feasible

Hawaii) face high incremental costs for air quality improvements. According to an Office of Technology Assessment report, "The generally favorable cost-effectiveness of early retirement programs in nonattainment areas does not apply to programs in areas complying with air quality standards" (U.S. Congress, 1992).

R.2 Further Study of Measures to Decrease Regional VMT

Issues associated with the implementation of one type of automobile use limitation, road pricing, include:

- cost of monitoring equipment;
- availability of reasonable alternatives to SOV travel;
- federal restrictions on tolls on federally funded highways;
- its apparent regressiveness; and
- details of the fee structure.

A new Environmental Defense Fund analysis (Environmental Defense Fund, 1994) claims to show that congestion pricing is not regressive and is very cost effective.

ISTEA funds are available to fund a pilot road pricing program, but although there is some local interest, Hawaii has not submitted an application to date.

Another way to reduce VMT is to transfer certain costs (such as automobile insurance and vehicle registration fees) from the basis of vehicle ownership to the basis of vehicle travel, making the incremental cost per vehicle-mile of travel more expensive. With the current system, if vehicle ownership costs are $3,500 per year, and incremental costs (gasoline, oil, maintenance, and tires) are 8 cents per mile, the total cost to drive 10,000 miles annually is 36 cents per mile. However, the total cost to drive 20,000 miles annually is 28 cents per mile (American Automobile Association, 1991). Transferring auto insurance to pay-at-the-pump (also known as a pay-as-you-drive system) would add approximately 5.09 cents to the price of a gallon of gasoline (El-Gasseir, 1990) with liability insurance being removed from vehicle ownership costs.

Under a pay-at-the-pump system, the high mileage driver would pay slightly less in total costs per year (due to fewer uninsured motorists on the road), but incremental costs as a proportion of total costs would change from 38 percent to 47 percent. This would provide greater incentive to reduce vehicle miles traveled. Fuels with lower energy content should be assessed less per gallon.

R.3 Research Fleet Rules

This is related to Measure A.13, fleet purchase requirements. Rather than direct implementation of fleet rules, the area could be researched, drawing upon fleet requirement experiences in other states, particularly those which implemented fleet rules as part of their air quality plans. The results of the research could be presented by DBEDT in informal working groups with fleets.

R.4 Identify Solutions To Hawaii-Specific Barriers to Alternative Fuels

Several barriers to the introduction of alternative fuels in Hawaii have been identified in this study; additional study and evaluation would answer questions and increase levels of confidence in several areas. For example, how can the cost and logistics of inter-island transport of small quantities of alternative fuels be improved? How would battery recycling work in Hawaii? How would an electric vehicle (EV)-friendly city provide EV quick-charging, opportunity charging, or even overnight charging for condominium dwellers or hotel guests? Which fleets have operational needs which are matched by a particular alternative fuel, and how can those fleets be identified?

Public perception of the alternative fuels may also be a barrier to acceptance and use of alternative fuels and AFVs. What are the particular aspects of alternative fuels which cause potential alternative fuel users in Hawaii the most concern? Which aspects are most attractive to potential alternative fuel users? Surveys, interviews, and "focus groups" have been used in other cities to identify answers to the "fuel attractiveness" questions; these cities may soon be compiling actual purchase data to validate and modify the results of their surveys and focus groups. Hawaii may be able to benefit from the survey instruments and approaches developed elsewhere, and to use them to determine Hawaii's specific concerns and interests.

R.5 Continue to Support and Expand Demonstration Programs

Demonstration programs have many benefits, including:

- the development and maintenance of the "intellectual infrastructure" for future AFV technology transfer;
- provision of an entry point for specific fuels, since demonstration programs could be the first step in a progression to larger introduction of AFVs and development of refueling infrastructure;
- sparking interest; and
- obtaining data.

There is currently a methanol demonstration program in the state. This should be considered the "alcohol" demonstration program. The price of ethanol should be monitored, and if and when ethanol seems appropriate, the demonstration program could be modified.

A demonstration program for heavy-duty alcohol engines and vehicles should be considered because the provision of alternative fuel vehicles in this sector needs encouragement. There is also an EV demonstration program in the state, the Hawaii Electric Vehicle Demonstrative Program (HEVDP). As discussed elsewhere, an EV purchase requirement may be appropriate at about the time the HEVDP winds down.

R.6 Monitor Demonstration Programs on Mainland

Hawaii should be informed by mainland experiences. This information may be forwarded to fleet managers and others through the outreach and public education measures.

R.7 Maintain Dialogue with Manufacturers on State Interest in Ethanol FFVs

Since the Hawaii light duty vehicle market is too small to affect manufacturer offerings, Hawaii will have to use the alcohol FFVs provided by the manufacturers. The state should keep abreast of methanol-ethanol conversion issues, and be sure the manufacturers know about Hawaii's interest in ethanol. Hawaii needs to monitor carefully the availability of ethanol vehicles. Encouraging the production of E85 FFVs may increase the likelihood of continued and increased availability of these vehicles.

R.8 Update and Refine Alternative Fuel Cost Estimates

It is important to update, refine and maintain the cost estimates presented in Chapter 8 to reevaluate issues of subsidies and fees as technology and other conditions change.

SECOND TIER TOPICS

R.9 AFV Incentives

This topic is related to Measure A.19 which states possible initial values for financial incentives. Also worthy of study, however, are non-financial incentives such as AFV access to HOV facilities, preferred parking arrangements, exempting AFVs from mileage standards, exempting AFVs from road pricing, and so on. To what degree could these non-financial incentives increase AFV adoption? It may be appropriate to propose non-financial AFV incentives along with financial incentives. The use of surveys and focus groups may be appropriate techniques to study these issues.

R.10 Monitor Manufacturer Offerings and Consumer Acceptance

The state should monitor manufacturer offerings, which are constantly changing, particularly including ethanol FFVs, which get less promotion than methanol FFVs. The domestic car manufacturers have staff knowledgeable about their alternative vehicle offerings, and these offerings could be monitored through periodic contact with appropriate staff. The state should also encourage manufactures to continue to study consumer acceptance of AFVs and share this information with the state so that the state can implement measures to encourage public adoption of AFVs. Finally, the state could monitor AFV adoption patterns in other states and adjust local programs in response to mainland experiences.

R.11 Monitor and Conduct Research on Biodiesel Compatibility with Existing Infrastructure

This topic should be studied in more detail to determine the extent of infrastructure barriers to biodiesel introduction, should the production costs of biodiesel fall in the future. Barriers could be regulatory as well as technical. One approach would be to analyze each step of the biodiesel production, distribution, blending and utilization cycle, and assess potential barriers at each step.

R.12 Study Further State Backing of Industrial Development Bonds

There will be repeated calls for the state to back alternative fuel production facilities. Rather than dealing with these piecemeal, a strategy to deal with these requests could be developed. For example:

- application and review cycles could be advertised so that competing projects could be reviewed simultaneously;
- review criteria that relate to state energy and economic development goals could be established and publicized; and
- categories of preferred projects could be established and publicized.

R.13 Monitor Progress in Reducing the Technical Barriers

The technical barriers affecting AFV use are constantly being addressed on the mainland. The state should monitor the removal of various technical barriers through newsletters, conferences, and communications with knowledgeable parties.

R.14 Monitor Research Using MSW and Other Wastes to Make Alcohol

MSW and other waste feedstocks are inexpensive, if not free. A working relationship between energy experts and solid waste experts should be maintained, and possible production of fuels from waste should continue to be discussed.

R.15 Evaluate Primary and Secondary Economic Impacts of a Local Fuels Production Industry

It will be important for the primary and secondary economic impacts of alternative fuels utilization and a local alternative fuels production industry to be assessed and publicized. Secondary impacts would include indirect employment (through direct and indirect purchases made by the new industry), a reduction in the flow of money out of state for energy purchases, increased state and local revenues, and, if the area is economically distressed, a reduction of emergency aid ("welfare") payments.

R.16 Further Evaluation of Cost And Logistics of Transport of Alternative Fuels Between Islands and Terminal Facilities

The logistics assumed in this study are conservative and based on current liquid fuel distribution facilities.[5] If ethanol blending was occurring on a large scale, new distribution facilities would probably be constructed to enhance efficiency. Previous ethanol blending was accomplished at an underground tank at Honolulu Harbor; this tank has since been removed. Tank re-installation near the existing gasoline distribution facilities or a storage tank at Barber's Point and a smaller one at the Honolulu gasoline terminal may enhance efficiency, depending on the ethanol production locations.

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[5] For example, the ethanol blending scenario assumes an ethanol terminal at Barber's Point and a gasoline terminal at Honolulu Harbor. The tanker truck driver would first go to Honolulu Harbor to load gasoline and then proceed to Barber's Point to load in 10% ethanol.

R.17 Survey of Hawaii-Specific Vehicle Purchase Preferences

The vehicle preferences used in this study were based on surveys conducted in California, and Hawaii purchasers may have different preferences. It may be possible to borrow California's survey method (thus avoiding development costs) and replicate the survey to determine Hawaii preferences. This would help refine estimates of types and magnitude of voluntary AFV purchases.

R.18 Survey of Fleets

Results could help to match AFVs to fleets whose needs and preferences fit the AFVs' attributes. This could be done as a joint cooperative project with private AFV manufacturers or converters, possibly through the "Honolulu Clean Cities" mechanism.

R.19 Fund Other Research as Appropriate and Feasible

Unanticipated research priorities could arise.

11.4.2 THE NEAR-TERM PROGRAM

Because alcohol blending is part of the recommended near-term program, research should focus on the issues specific to Hawaii's alternative fuel program, such as cost and logistics of transporting alcohol between terminal facilities. Research on alcohol production from crops is timely because of the recent changes in Hawaii's agricultural industry. Economic impacts of local fuel production should be evaluated.

Additional research and development plans should focus on programs to evaluate fleet purchase requirements and their efficiency in other states. Rather than impose an arbitrary system in Hawaii, experiences in other states, especially those that imposed fleet rules for air quality, should be examined.

Methods to reduce the number of vehicle miles traveled and programs to increase fuel efficiency should continue to be part of the state's transportation research agenda.

11.4.3 STAFFING

Each of the above measures would require some degree of staffing. Staffing requirements of major measures are estimated in Table 11-6.

Table 11-6.
Estimated Staffing Requirements Associated With Research and Development Measures

Measure #	Description of Measure	Estimated Staffing
	First Tier	
R.1	Feasibility study on increasing in-state vehicle fuel efficiency	0.20
R.2	Further Study of Measures to Decrease Regional VMT	0.10
R.3	Draft fleet rules	0.50
R.4	Study of Hawaii-specific, non-cost barriers to alternative fuels	0.10
R.5	Continued support and expansion of demonstration programs	0.25
R.6	Monitoring of demonstration programs on the mainland	0.10
R.7	Maintaining dialogue with manufacturers on state interest in ethanol FFVs	0.10
R.8	Updating and refining alternative fuel cost estimates	0.15
	Second Tier	
R.9	Study of incentives for AFVs	0.25
R.10	Monitoring manufacturer offerings and consumer acceptance	0.10
R.11	Evaluation of biodiesel compatibility with existing infrastructure	0.20
R.12	Study further state backing of industrial development bonds	0.10
R.13	Monitor progress in reducing the technical barriers	0.25
R.14	Monitor research using MSW and other wastes to make alcohol	0.10
R.15	Evaluate impacts of local fuel production	0.25
R.16	Evaluate cost and logistics of transport	0.25
R.17	Survey Hawaii-Specific Vehicle Purchase Preferences	1.00
R.18	Survey Fleets	0.20
R.19	Fund other research as appropriate and feasible	0.10

11.4.4 FUNDING

Some of the measures described may be self-supporting, particularly those with immediate benefits to participants, such as cost savings. Several of the programs may be funded with federal grants. Cooperative arrangements may also reduce public sector costs and increase success, especially for those programs for which investment decisions will be based on the results of the research and development work.

11.5 MONITORING

Tracking the cost and effectiveness of the transportation energy measures will allow the most effective elements to be identified and strengthened, and less-effective or overly costly elements to be revised or discontinued.

11.5.1 MONITORING PROGRAMS

Potential monitoring programs are listed in Table 11-7.

Table 11-7.
Potential Monitoring Programs

Type of Measure	Description
Monitoring Programs (M)	M.1 Address data deficiencies M.2 Update energy demand projections M.3 Monitor and report on effectiveness of requirements and incentives

It is important to improve the state's energy statistics. Key information to be collected in the area of transportation energy include:

- data on vehicle exports and scrap rate to be able to calculate fleet turnover better;
- annual miles traveled per vehicle; and
- number of vehicles in centrally fueled fleets.

The known problems with the Act 65 data indicate a need for better quality assessment/quality control (QA/QC) on the data collected. There is also a need to centralize the data on energy parameters.

Appropriate data collection systems will need to be developed so that there is appropriate data for the periodic Energy Resource Coordinator reports. Such parameters as alternative fuel volumes, petroleum displacement, and numbers of AFVs will need to be collected.

Data collection is a key step for the state's energy program. Without accurate data to develop and guide the program, legislative decisions will be stalled and consumers will not support alternative energy in the transportation sector.

11.5.2 STAFFING

Each of the above measures would require some degree of staffing; staffing requirements of measures are estimated in Table 11-8.

Table 11-8.
Estimated Staffing Requirements Associated With Monitoring Measures

Measure #	Description of Measure	Estimated Staffing
M.1	Address data deficiencies	0.10
M.2	Update energy demand projections	0.10
M.3	Monitor and report on effectiveness of requirements and incentives	0.10

11.6 SUMMARY/CONCLUSIONS

This report is the basis for an action plan to influence energy use in the ground transportation sector. Experience on the mainland and elsewhere has shown the need for successful programs to be integrated, publicly-supported packages of requirements, incentives, research, outreach and public information, governmental actions and monitoring programs. Because of these interrelationships, it is appropriate to integrate all elements relating to ground sector energy use into a package addressing conservation, alternative fuel supply and demand, and AFV supply and demand.

An alcohol gasoline blend program is the most cost-effective means of encouraging the use of significant quantities of renewable, locally produced alternative fuels. As discussed in Chapter 10, projected costs may be justifiable since jobs would be preserved and created immediately as energy crop production commenced.

State transportation energy efforts should focus on energy conservation and to a lesser degree, congestion relief. The goal of energy conservation efforts would be to increase the average fuel efficiency of motor vehicles in the state and change travel behavior and land use patterns. Improving and expanding public transportation and other methods of decreasing vehicle miles traveled would have immediate energy savings, while transportation and land use planning would have the greatest projected long-term energy conservation potential. The near-term program should focus on improvements to public transportation, the organization of transportation management associations and actions by educational institutions.

Research and development programs would also play an important part in the achievement of Hawaii's energy goals. In the near-term the state should research such areas as alcohol production and transportation, fleet purchase requirements and their effectiveness in other states, methods to reduce the number of vehicle miles traveled, and programs to increase fuel efficiency.

Reduced cost off-peak rates for EV recharging, adjusting fuel taxes based on energy content, and public education programs are recommended low-cost and low-risk components of a near-term alternative fuels program.

The near-term alternative fuels program would last about seven years. By that time it is estimated that about 10,000 alternative fuel vehicles would be in use in Hawaii. At the beginning of the mid-term program, it would be appropriate to reevaluate the cost, availability and desirability of the various alternative fuel vehicles and incentives. Fleet incentives and mandates may also be part of the mid-term program. In the mature program, alternative fuels would have achieved cost-effective scales of production and distribution, and government subsidies and incentives would be phased out.

A balanced approach incorporating conservation, alternative fuel measures, research and development, out reach and monitoring is recommended for the ground transportation sector. Reduced off-peak recharging rates for EVs, fuel taxes based on energy content and public education programs are essential first steps in a program to encourage continued and expanded use of alternative fuels and vehicles. Alcohol blending, fleet purchase mandates and vehicle purchase incentives could also be implemented. Conservation measures such as public transportation, transportation management associations and actions by educational institutions, must be central to state policy if congestion and the number of vehicle miles traveled are to be reduced. Research and monitoring of ground transportation sector energy issues need to continue and the public must be educated and informed of the options and policies affecting transportation in the state.

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APPENDICES

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APPENDICES

APPENDIX A-1

CALCULATION METHODS

A-1: CALCULATION METHODS

A-1.1 GROUND TRANSPORTATION ENERGY CONSUMPTION

A-1.1.1 METHODOLOGY

Future ground sector energy demand was estimated as follows:

1. Determine the number of vehicles registered per county for the latest year data is available (Hawaii State Data Book). For this analysis, the most recent year for which data is available was 1992, which therefore becomes the "baseline" year.

2. Determine the number of vehicles in each of eight vehicle categories (Hawaii State Data Book).

3. Determine ground sector fuel use by county for the baseline year (Department of Taxation data).

4. Correct (3) by the amount of fuel "wasted" due to congestion losses. The calculation of fuel "wasted" due to congestion is patterned after the methodology of the Texas Transportation Institute (1994) and is shown in Figure A1-1. Since the inputs required for the congestion loss calculations were only available for Oahu, percentage of fuel "wasted" due to congestion on the neighbor islands was to be equal to the percentage of fuel "wasted" due to congestion on Oahu.

5. Determine average fuel use per vehicle per county, after deducting the amount of fuel "wasted" due to congestion losses: (4) divided by (1).

6. Determine projected annual increase in ground transportation activity per county (from county transportation plans).

Figure A1-1

CALCULATION OF ENERGY WASTED DUE TO CONGESTION

Definitions

Link Congestion Levels:

Freeway

Uncongested: Average Daily Traffic (ADT) per lane under 15,000
Moderate Congestion: ADT per lane 15,000 - 17,500
Heavy Congestion: ADT per lane 17,501 - 20,000
Severe Congestion: ADT per lane over 20,000

Arterial

Uncongested: ADT per lane under 5,750
Moderate Congestion: ADT per lane 5,750 - 7,000
Heavy Congestion: ADT per lane 7,001 - 8,500
Severe Congestion: ADT per lane over 8,500

Assumptions

Average Link Speeds:

Freeway

Uncongested: 100 kilometers per hour (kph)
Moderate Congestion: 61 kph
Heavy Congestion: 53 kph
Severe Congestion: 48 kph

Arterial

Uncongested: 60 kph
Moderate Congestion: 45 kph
Heavy Congestion: 40 kph
Severe Congestion: 37 kph

Figure A1-1

CALCULATION OF ENERGY WASTED DUE TO CONGESTION (Continued)

- Annualization factor - 250 days per year
- 45 percent of Average Daily Traffic occurs during peak periods
- Average daily arterial incident delay equals 1.1 times average daily recurring delay
- Average daily freeway incident delay equals 1.8 times average daily recurring delay (specific to Honolulu)

Input Data

Total daily Vehicle Miles of Travel (VMT) by facility type and congestion level:

Freeway: Uncongested, Moderated Congestion, Heavy Congestion, Severe Congestion
Arterial: Uncongested, Moderate Congestion, Heavy Congestion, Severe Congestion

Calculations

- Convert VMT by facility type and congestion level to Vehicle Kilometers of Travel (VKT)
- Calculate Vehicle Hours of Travel (VHT) by facility type and congestion level:
  VHT = VKT/Average Speed (in kph)
- Sum congested VHT by facility type (i.e., Moderate Congestion VHT + Heavy Congestion VHT = Severe Congestion VHT)
- Sum congested VKT by facility type (i.e., Moderate Congestion VKT + Heavy Congestion VKT + Severe Congestion VKT)
- Calculate peak period congested VHT by facility type:
  Peak period congested VHT = Daily congested VHT * 0.45
- Calculate peak period congested VKT by facility type:
  Peak period congested VKT = Daily congested VKT * 0.45
- Calculate, by facility type, the average peak period congested speed:
  Average congested speed = peak period congested VKT/ peak period congested VHT

Figure A1-1

CALCULATION OF ENERGY WASTED DUE TO CONGESTION (Continued)

- Calculate, by facility type, the VHT which would be spent by vehicles on congested facilities if those facilities operated at an uncongested speed:
  Peak period congested VHT, if uncongested = peak period congested VKT/ uncongested average speed
- Calculate, by facility type, average daily peak period recurring hours of delay:
  Recurring hours of delay = peak period congested VHT - peak period VHT, if uncongested
- Calculate daily freeway hours of incident delay:
  Freeway incident hours of delay = freeway recurring hours of delay * 1.8
- Calculate daily arterial hours of incident delay:
  Arterial incident hours of delay = arterial recurring hours of delay * 1.1
- Calculate, by facility type, total daily hours of delay:
  Daily hours of delay = recurring hours of delay + incident hours of delay
- Calculate, by facility type, average fuel economy of vehicles operating in congestion:
  Average fuel economy = 3.74 + (0.11 * average congested speed) x (liters per kilometer)
- Calculate, by facility type, average daily fuel consumed during hours of delay:
  Daily fuel consumed during delay = daily hours of delay * average congested speed/ average fuel economy
- Calculate total daily fuel consumed during hours of delay:
  Daily fuel wasted = daily fuel consumed during freeway delay + daily fuel consumed during arterial delay
- Calculate annual fuel wasted:
  Annual fuel wasted due to congestion = 250 * daily fuel wasted
- Convert annual fuel wasted from liters to barrels

Sources: Parsons Brinckerhoff Quade & Douglas, Inc.
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7. Determine number of vehicles per county for the future projection year. It is assumed that vehicle miles traveled (VMT) per year per vehicle stays constant:[1] On a per county basis, multiply (1) by (6) raised to the power of the difference in years between the projection year and 1992. This calculation increases the vehicle population at the rate of increase in transportation activity (essentially modeling future travel demand increases as an increase in the number of vehicles).

8. Determine future mix of vehicles based on historical trends (i.e. number of light trucks increasing at a faster rate).

9. Determine (as a percentage improvement from the baseline year) expected future vehicle efficiency through Corporate Average Fuel Efficiency (CAFE) standards (from Forecast of Transportation Energy Demand Through the Year 2010 (Argonne National Laboratory, 1991).

10. Determine future level of fuel "wasted" due to congestion using the method shown in Figure A1-1.

11. Determine net level of future fuel consumption per county: discount (5) by (9), multiply by (7).

12. Determine total future fuel consumption: add (10) to (11).

13. Sum future county demands to obtain total state demand.

Based on this approach, total ground sector fuel demand would increase from 9.8 million gasoline-equivalent barrels (GEB) in 1992 to 10.3 million GEB in 1996, 10.6 million GEB in 1999, 10.9 million GEB in 2004, and 12.4 million GEB in 2014. These increases correspond to an annual rate of growth of about 1.05 percent between 1993 and 2014.

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[1] This is consistent with the assumptions in use by the State Department of Transportation at the time their forecasts were prepared. The number of vehicles is used in these calculations essentially as a means of describing a relationship between transportation activity and fuels use, and when the number of vehicles is converted back to fuel demand, the assumption of constant VMT/vehicle becomes irrelevant due to the factors cancelling out of the equation. In general, the non-congestion fuel was determined as follows:
(VMT/VEH)(current) x **VEH**(current) = **VMT**(current)
FUEL(current) ÷ **VEH**(current) = **(FUEL/VEH)**(current)
(VMT/VEH)(current) ÷ **(FUEL/VEH)**(current) = **MPG**(current)
MPG(current) x **(MPG CHANGE RATE)**$^{(\#\text{ years})}$ = **MPG**(future)
VMT(current) x **(VMT CHANGE RATE)**$^{(\#\text{ years})}$ = **VMT**(future)
(VMT/VEH)(future) ÷**MPG**(future) = **(FUEL/VEH)**(future)
VMT(future) ÷ **(VMT/VEH)**(future) = **VEH**(future)
(FUEL/VEH)(future) x **VEH**(future) = **FUEL**(future)

A-1.1.2 DISCUSSION

Some of the issues associated with this method include:

- A main "driver" of the projections are the average annual rates of increase in ground transportation activity projected for each county, as follows:
  - Kauai: 3.47 percent increase in daily vehicle trips (Kauai County Highway Planning Study - Final Report, October 1990);
  - Hawaii: 3.19 percent increase in daily traffic volumes (Island of Hawaii Long-Range Highway Plan Final Report, May 1991);
  - Maui: 3.93 percent increase in daily vehicle trips (Maui Long-Range Highway Planning Study - Island Wide Plan - Final Report, May 1991); and
  - Honolulu: 1.13 percent increase in vehicle miles traveled (VMT).[2]

  Of the three travel parameters used above (daily vehicle trips, daily traffic volumes and VMT), VMT is most closely linked to energy demand. Because VMT estimates for the Neighbor Islands were not readily available, it was assumed that the percentage increases in the other travel parameters would be indicative of the increase in VMT on the Neighbor Islands.[3]

- Diesel and gasoline are commingled in the estimation. In future refinements, the calculation could be performed separately for gasoline and diesel if data on vehicle registrations by vehicle type by county were readily available, and assumptions were made about the relative use of gasoline and diesel by trucks.
- It is assumed that VMT per vehicle and trips per vehicle remain constant (see footnote 1).
- Percentage energy efficiency improvements expected for passenger vehicles were used to model efficiency improvements for the total state fleet because of the preponderance of passenger vehicles in the state fleet (see Figure 2-7). The assumed increase in energy efficiency turned out to have a major effect on future demand. In future refinements, efficiency improvements for each vehicle class could be considered separately. Also, since the Forecast of Transportation Energy Demand Through the Year 2010 (Argonne National Laboratory, 1991) only predicts fuel efficiency through 2010, it was assumed that 2010 energy efficiency levels applied through 2014.

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[2] The Oahu Regional Transportation Plan (1991) contains projections based on three different scenarios. The three projections were combined to obtain the 1.13 percent increase.

[3] It should be noted that all of the county plans from which the increases in transportation activity were obtained are currently being updated. Revised plans are expected in 1995.

A-1.1.3 COMPARISON OF THE PROJECTION WITH OTHER ANALYSES

The Hawaii Statewide Transportation Plan (STP) (Statewide Transportation Council and Department of Transportation, 1991) includes projections of DOT revenues from state fuel taxes on gasoline and diesel. These projections indicate an annual increase in fuel sold averaging 1.2 percent for the period between 1992 and 1997.[4] This rate is higher than the 1.05 percent annual growth predicted by HES-5 between 1993 and 2014.

Forecasting a State-Specific Demand for Highway Fuels: The Case for Hawaii (PingSun Leung and Mary H. Vesenka, 1987) contains the following fuel consumption projections:

Highway Fuel Consumption Projection for 2000

Low Fuel Price	18 million barrels
Mid Fuel Price	11 million barrels
High Fuel Price	9 million barrels

This project forecasts fuel consumption of 10.6 million barrels for the year 1999. This projection is consistent with the projections listed above, falling quite close to the "mid fuel" price scenario.

A-1.2 AIR TRANSPORTATION ENERGY CONSUMPTION

A-1.2.1 METHODOLOGY

Future aviation sector energy demand was estimated as a function of passenger volumes and per capita fuel requirement according to the formula $F = B*N$, where:

F = fuel consumption
B = per capita requirement (volume of fuel per passenger)
N = number of passengers

Interisland and overseas energy demands were calculated separately and then summed to obtain total aviation demand.

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[4] The STP is being revised in early 1995.

Data for B and N came from the following sources:

- N: Historical values were obtained from Airport Statistical Data (DOT), a data set including passenger volumes and cargo and mail tonnage distributed between "overseas" and "interisland" flights for all commercial airports in the state. The Hawaii Statewide Airport System Plan (Wilson Okamoto & Associates, Inc., 1990) provides forecasts of passenger volumes and cargo and mail tonnage apportioned between "interisland" and "overseas" flights for 1995, 2000, 2005, and 2010. Passenger volumes were used to drive the HES-5 projections. Aircraft operations (landings and departures) could have been used to drive the projections instead of passenger volumes, but the data on aircraft operations does not separate "interisland" and "overseas" operations. The Hawaii Statewide Airport System Plan (Wilson Okamoto & Associates, Inc., 1990) projects an annual average growth rate of passenger volumes of 2.29 percent. The forecasts were prepared in 1990 during a period of rapid growth in passenger and cargo volumes. Actual data in subsequent years do not reflect the growth in the aviation section projected by Wilson Okamoto & Associates, Inc. (1990).
- B: The interisland and overseas per capita fuel requirement is the ratio of fuel purchased to the number of interisland or outbound overseas passengers. An average of these ratios for the years 1989 to 1993 was used for the projections.

Total fuel consumption was obtained from the Department of Taxation data, which needed to be manipulated because interisland and overseas fuel purchases are combined. To separate the two fuel markets, since Act 65 distinguishes interisland and overseas purchases, the Department of Taxation total aviation purchase was allocated according to the split between interisland and overseas purchases as shown in the Act 65 data for each year. To allocate the Department of Taxation data for the years for which Act 65 data was not available (1991 and 1993), the average allocation from the Act 65 data for the years 1988, 1989, 1990 and 1992 was used (20 percent interisland; 80 percent overseas).

Since fuel efficiency is expected to improve through technology and operating practices,[5] this effect was used to adjust the per capita fuel requirement. The Forecast of Transportation Energy Demand Through the Year 2010 (Argonne National Laboratory, 1991) expresses improvements in fuel efficiency as BTU's per revenue passenger mile. Argonne National Laboratory (ANL), the Federal Aviation Administration (FAA), and the Energy Information Administration (EIA) forecasted annual aviation efficiency improvements from 1985 to 2010 of 1.61 percent, 1.73 percent, and 1.88 percent, respectively. An average of these, 1.74 percent, was used in the HES-5 projections.

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[5] For further discussion, see Chapter 3.

A-1.2.2 COMPARISON WITH OTHER PROJECTIONS

A Study of the Aviation Fuels Industry in Hawaii for the Purpose of Energy Emergency Preparedness (Ed Noda & Associates, 1992) projects a demand of 21,754,000 barrels in 1995 and 31,645,500 barrels in 2010. HES-5 calculations project a demand of 16,877,333 barrels in 1995 and 20,507,875 barrels in 2010, approximately one quarter to one third less than Ed Noda & Associates' projections. Phase II Report on A Relocation Program and Development Plan for Petroleum-Oil-Lubricants (POL) Facilities in the Oahu Waterfront (William Brothers, 1992) presented a forecasted fuel demand in 2010 of 33 million barrels, around 13 million gallons more than the HES-5 calculations. These projects tend to overestimate demand because they are based on data available in 1992. In 1993, air transportation demand dropped significantly (refer to Figure 2-7).

A-1.3 MARINE TRANSPORTATION ENERGY CONSUMPTION

A-1.3.1 METHODOLOGY

Future marine sector energy demand was estimated as a function of projected cargo tonnage and fuel requirement per cargo ton according to the formula F = B*N, where:

F = fuel consumption
B = gallons bunkered per cargo ton
N = cargo tonnage

Fuel consumption for interisland and outbound components of marine trade were calculated separately, and the energy demand of recreational boating was also included.

Data for B and N came from the following sources:

- B: Fuel consumption per cargo ton was calculated separately for interisland and overseas marine movements. Fuel consumption was obtained from Act 65 data, which partitions marine fuel use between interisland and overseas activities. The State Department of Transportation, Harbors Division has data on cargo tonnage partitioned between inbound and outbound, overseas and interisland movements for each commercial port in the state.

From 1983 to 1987, fuel utilization rates for both interisland and outbound overseas freight remained relatively stable. Between 1987 and 1989, however, the value for interisland movements decreased substantially, while the value for overseas movements climbed substantially. After 1989, these utilization rates became more stable. The average fuel utilizations for 1989 and 1990 were used for the projections.

Transportation Energy Demand Through the Year 2010 (Argonne National Laboratory, 1991) for essentially no change in marine sector fuel efficiency include:

- Engine replacements to increase fuel efficiency have already occurred;
- Even though new engine technology improvements such as turbocompounding and rankine bottoming cycles have demonstrated fuel savings, these technologies have not been made commercially available; and
- Since engine replacement cycles are typically quite long (30 years or more), the slow rate of engine turnover will delay improvements in marine fuel efficiency.

- N: Harbors Division's statistics on cargo tonnage distinguish interisland and overseas movements. Between 1983 and 1990, interisland tonnage increased an annual rate of 6.2 percent and outbound overseas cargo tonnage grew at an annual rate of 1.2 percent. (Inbound overseas cargo is excluded from this analysis since it arrived with fuel bunkered elsewhere.)

There are no readily available statewide projections of cargo tonnage. It was assumed that the historical tonnage growth rate for interisland and overseas movements would continue, so that total tonnage is projected to increase from 10.7 million in 1990 to about 24.5 million in 2014, corresponding to annual growth of about 3.5 percent.

Information on recreational boating activity was obtained from Small Craft Mooring Facilities Utilization Report (DLNR, 1992) and Report of Undocumented Vessel Registration for 1991 (DOT). There were about 14,000 recreational vessels registered in the state between 1989 and 1991. Fuel use by recreational boats was about 84,000 barrels in 1991, yielding an average bunkering rate for recreational boats of about six barrels per boat per year. The impact of recreational boating on marine sector fuel demand is minimal.

A-1.3.2 COMPARISON TO PROJECTIONS BY OTHERS

Petroleum Facilities - Honolulu Waterfront Master Plan Technical Report (Jason Lembeck & Associates, 1989) projected a very small and relatively stable marine fuel demand from 1998 to 2010 for the state as a whole. For 2010, it only projected about a quarter of the total marine fuel demand predicted by this study.

A cargo forecast for the Island of Hawaii in 1990, Cargo Forecast for the Island of Hawaii (Manalytics, 1990), projected a rate of cargo increase of 2.93 percent from 1990 to 2010. This is relatively close to the marine fuel demand increase projected by this study, 2.37 percent from 1993 to 2014.

APPENDIX A-2

HISTORICAL FUEL USE AND VEHICLE REGISTRATION DATA

Aviation Fuel Use														
	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Statewide (gallons)	489,550,885	474,477,404	501,647,961	485,810,403	538,054,749	603,166,662	693,742,014	701,555,232	732,883,315	750,789,774	729,377,748	711,401,933	599,691,308	641,589,051
Statewide (barrels)	11,655,973	11,297,081	11,943,999	11,566,914	12,810,827	14,361,111	16,517,667	16,703,696	17,449,603	17,875,947	17,366,137	16,938,141	14,278,364	15,275,930

Source: DOTax, Records

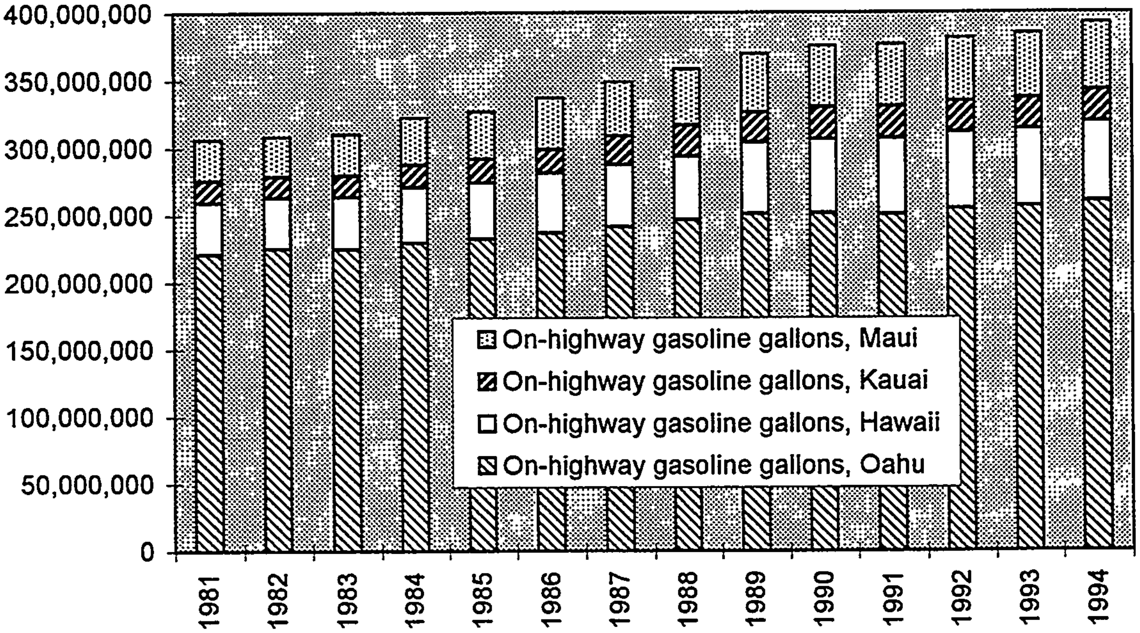
Marine Fuel Use														
	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Statewide (gallons)	61,107,102	55,811,196	49,298,424	57,954,330	39,507,636	45,875,634	70,098,210	117,809,790	161,184,534	173,119,800	244,883,058	184,138,290	168,886,914	164,038,770
Statewide (barrels)	1,454,931	1,328,838	1,173,772	1,379,865	940,658	1,092,277	1,669,005	2,804,995	3,837,727	4,121,900	5,830,549	4,384,245	4,021,117	3,905,685

Source: DBEDT, Records

Ground Fuel Use														
	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
On-highway gasoline gallons, Oahu	220,532,532	224,861,603	224,182,276	229,080,808	232,092,035	236,287,179	240,715,852	245,931,095	250,447,291	250,799,527	249,601,124	254,097,008	256,027,346	259,924,734
On-highway gasoline gallons, Hawaii	38,890,738	38,212,319	39,296,793	41,388,164	41,872,370	44,480,318	46,497,587	47,519,262	53,194,394	55,302,993	56,791,819	56,883,480	57,541,780	58,920,392
On-highway gasoline gallons, Kauai	15,889,461	15,627,025	15,444,538	16,482,109	17,616,326	17,680,880	21,377,685	22,859,891	22,160,844	23,584,340	23,824,885	23,133,688	22,663,691	23,234,754
On-highway gasoline gallons, Maui	30,573,264	29,898,687	31,161,558	35,458,630	35,440,692	38,110,216	39,882,682	41,675,829	43,369,073	45,695,562	45,963,956	47,004,252	48,211,176	50,324,359
On-highway gasoline gallons, State	305,885,995	308,599,633	310,085,164	322,409,710	327,021,423	336,558,592	348,473,806	357,986,078	369,171,601	375,382,422	376,181,784	381,118,428	384,443,993	392,404,239
On-highway diesel gallons, Oahu	11,191,438	11,362,274	11,825,805	12,685,118	12,848,216	14,424,076	15,643,085	15,126,246	16,486,477	16,549,015	17,239,068	18,530,363	16,702,196	18,623,235
On-highway diesel gallons, Hawaii	2,168,050	2,353,875	2,636,176	3,098,445	2,870,565	3,018,472	3,195,210	3,130,732	4,311,301	4,766,446	4,632,708	4,453,488	4,633,481	5,848,138
On-highway diesel gallons, Kauai	828,578	640,408	688,804	470,298	577,512	379,201	592,004	698,154	615,402	824,223	713,341	863,467	1,045,405	1,985,192
On-highway diesel gallons, Maui	1,582,524	2,946,839	1,289,574	1,638,589	1,339,956	1,532,306	1,776,909	2,101,885	2,316,264	2,623,023	2,405,849	2,441,198	2,616,329	3,235,395
On-highway diesel gallons, State	15,770,590	17,303,396	16,440,359	17,892,450	17,636,248	19,354,055	21,207,208	21,057,017	23,729,443	24,762,706	24,990,966	26,288,515	24,997,411	29,691,959
Total on-highway gasoline & diesel (bbls)	7,658,490	7,759,596	7,774,417	8,102,432	8,206,135	8,474,111	8,801,929	9,024,836	9,354,787	9,527,265	9,551,732	9,700,165	9,748,605	10,049,909

Source: DOTax, Records

Historical fuel use data

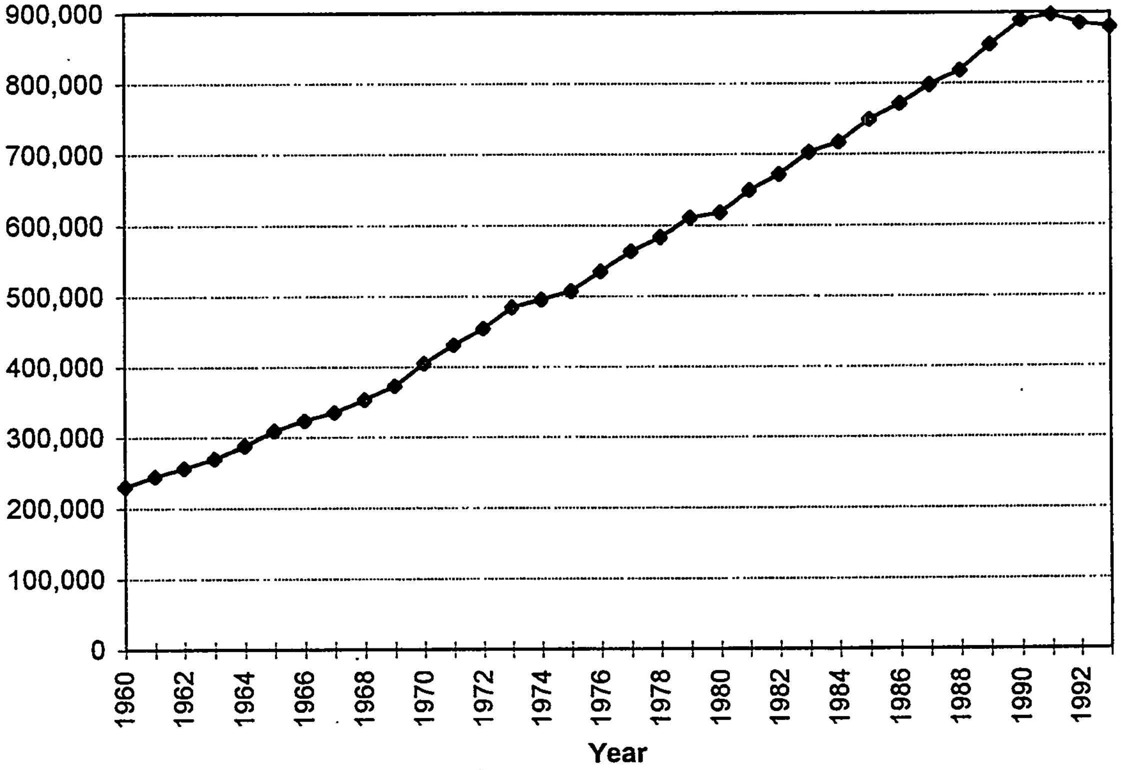


Historical sales of gasoline

year	Statewide De Facto Population	Statewide Resident Population	Statewide Registered Vehicles					Vehicles per Person (de facto population)
			Oahu	Hawaii	Kauai	Maui County	State Total	
1971	833,100	801,600	338,219	42,227	19,592	31,381	431,419	0.52
1972	869,800	828,300	354,544	45,316	20,766	34,203	454,829	0.52
1973	901,300	851,600	375,763	49,053	22,167	37,538	484,521	0.54
1974	923,700	868,000	381,502	51,064	22,802	39,669	495,037	0.54
1975	943,500	886,200	387,558	53,124	23,764	41,988	506,434	0.54
1976	970,300	904,200	406,149	57,151	25,300	46,617	535,217	0.55
1977	992,300	918,300	424,892	60,374	26,920	51,778	563,964	0.57
1978	1,014,300	931,600	436,347	63,025	27,614	56,615	583,601	0.58
1979	1,042,700	953,300	452,449	67,718	29,492	60,911	610,570	0.59
1980	1,055,400	968,500	454,316	70,047	30,604	62,604	617,571	0.59
1981	1,062,600	978,200	476,995	75,812	32,932	63,611	649,350	0.61
1982	1,084,600	993,800	495,629	77,024	33,931	64,929	671,513	0.62
1983	1,109,200	1,012,700	515,002	80,090	35,365	72,397	702,854	0.63
1984	1,130,500	1,027,900	525,599	80,840	35,236	75,496	717,171	0.63
1985	1,137,800	1,039,700	544,976	85,806	37,659	80,593	749,034	0.66
1986	1,167,500	1,051,800	556,935	89,918	40,585	84,137	771,575	0.66
1987	1,186,500	1,067,900	571,738	93,095	43,925	89,559	798,317	0.67
1988	1,200,400	1,079,800	579,998	96,360	47,235	94,016	817,609	0.68
1989	1,245,600	1,094,600	599,379	103,724	51,455	100,499	855,057	0.69
1990	1,257,000	1,112,900	612,742	110,834	55,927	109,593	889,096	0.71
1991	1,275,900	1,134,900	613,119	113,265	57,751	113,058	897,193	0.70
1992	1,272,100	1,155,700	611,513	113,080	51,165	110,003	885,761	0.70
1993	1,271,200	1,171,600	604,602	111,138	54,068	110,344	880,152	0.69

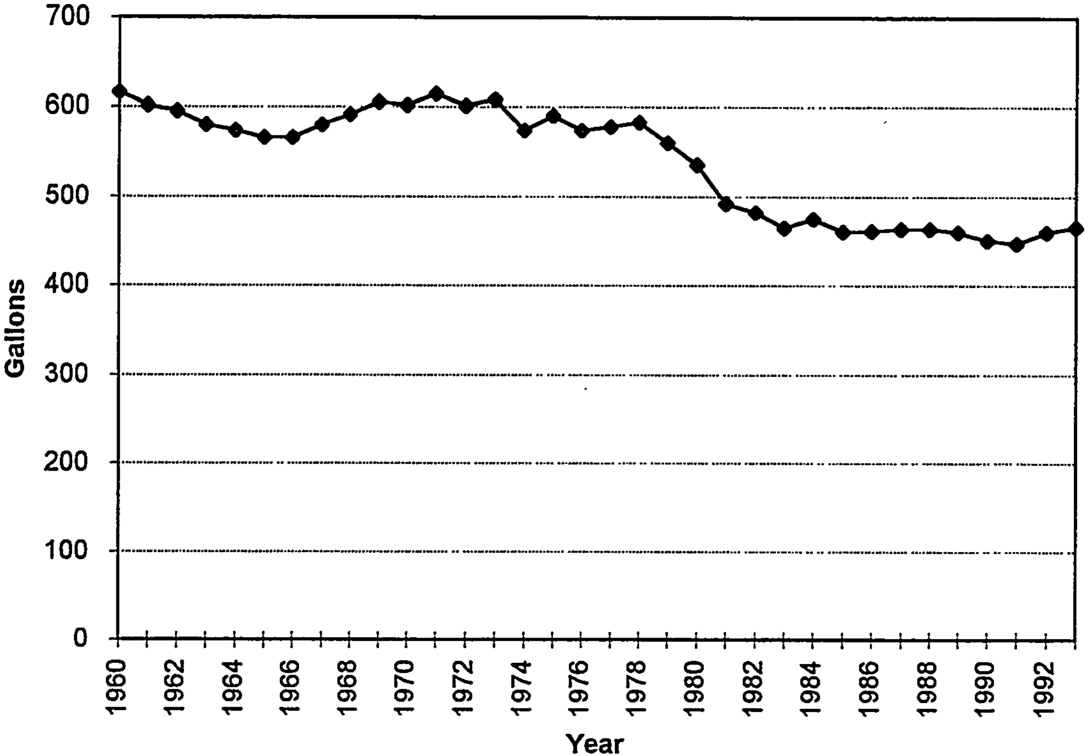
Registered Vehicles and Population

Number of Registered Vehicles in Hawaii, 1960-1993



Source: State of Hawaii, DBEDT, Data Book records

Annual On-Highway Fuel Use Per Registered Vehicle in Hawaii, 1960-1993



Source: State of Hawaii, DBEDT, Data Book records

APPENDIX A-3

COST ESTIMATES OF ALCOHOL FUEL USE IN HAWAII

SCENARIO
M85
Methanol (6000 gpy, containerized) Shipped from Mainland, Sold as M85 (M1a)
Methanol (170000 gpy, containerized) Shipped from Mainland, Sold as M85 (M1a)
Methanol (714000 gpy, parcel tanker) Shipped from Mainland, Sold as M85 (M1b)
Methanol (1.3 mgpy, parcel tanker) Shipped from Mainland, Sold as M85 (M1b)
Methanol (10 mgpy) from Banagrass on Oahu, Sold as M85 (M2a)
Methanol (59 mgpy) from Banagrass on Oahu, Sold as M85 (M2a)
Methanol (184 mgpy) from Banagrass on Oahu, Sold as M85 (M2a)
Methanol (1247 mgpy) from Coal on Oahu, Sold as M85 (M2b w/electricity)
Methanol (1247 mgpy) from Coal on Oahu, Sold as M85 (M2b, no electricity)
Methanol (10 mgpy) from Neighbor Island Banagrass, Shipped to Oahu, Sold as M85 (M3)
Methanol (67 mgpy) from Neighbor Island Banagrass, Shipped to Oahu, Sold as M85 (M3)
Methanol (375 mgpy) from Neighbor Island Banagrass, Shipped to Oahu, Sold as M85 (M3)
E85
Ethanol (6000 gpy, containerized) Shipped from Mainland, Sold as E85 (E1a)
Ethanol (170000 gpy, containerized) Shipped from Mainland, Sold as E85 (E1a)
Ethanol (7 mgpy) from Waste on Oahu, Sold as E85 (E2a)
Ethanol (30 mgpy) from Waste on Oahu, Sold as E85 (E2a)
Ethanol (1 mgpy) from Molasses, Shipped to Oahu, Sold as E85 (E3a)
Ethanol (3 mgpy) from Molasses, Shipped to Oahu, Sold as E85 (E3a)
Ethanol (7 mgpy) from Sugarcane on Oahu, Sold as E85 (E4a)
Ethanol (30 mgpy) from Sugarcane on Oahu, Sold as E85 (E4a)
Ethanol (60 mgpy) from Neighbor Island Sugarcane, Shipped to Oahu, Sold as E85
Ethanol (100 mgpy) from Neighbor Island Sugarcane, Shipped to Oahu, Sold as E85
E10
Ethanol (6000 gpy, containerized) Shipped from Mainland, Sold as E10 (E1b)
Ethanol (170000 gpy, containerized) Shipped from Mainland, Sold as E10 (E1b)
Ethanol (7 mgpy) from Waste on Oahu, Sold as E10 (E2b)
Ethanol (30 mgpy) from Waste on Oahu, Sold as E10 (E2b)
Ethanol (1 mgpy) from Molasses, Shipped to Oahu, Sold as E10 (E3b)
Ethanol (3 mgpy) from Molasses, Shipped to Oahu, Sold as E10 (E3b)
Ethanol (7 mgpy) Produced from Sugarcane on Oahu, Sold as E10 (E4b)
Ethanol (30 mgpy) Produced from Sugarcane on Oahu, Sold as E10 (E4b)

Scenario M1a	
Methanol (6000 and 170000 gpy, containerized) Shipped from Mainland, Sold as M85 (M1a)	
Annual demand/supply (1000 gal M85)	7
Annual demand/supply (1000 gal M85)	200
Shipping container (tank) size (gal)	6,100
Number of refueling locations	1
Shipping cost per container (low)	$4,000
Shipping cost per container (high)	$6,000
CEC methanol reserve price (low)	$0.42
CEC methanol reserve price(high)	$0.50
Hauling (loaded rate/hr)	$75.00
Time elements per truck trip (minutes)	
Driving to harbor	45
Travel to station	25
Transfer to underground tank	60
Return empty tank	30
Wholesale transaction tax	0.50%
Gasoline price @ rack (/gal gasoline)	$0.885
Tankwagon margin/gal	$0.03
Transaction cost margin/gal	$0.03
Additional cost margin/gal	$0.03
Tankwagon (loaded rate/hr)	$150.00
Tankwagon time (hrs/station)	0.5
Retail refueling facility installation cost (low)	$0
Retail refueling facility installation cost (high)	$103,000
Retail station business tax rate	28.65%
Interest rate	10.00%
nper (periods)	20
Max. deductible for fueling facility	$100,000
Refueling facility life (years)	20
Refueling facility cost after tax deduction (low)	$0
Refueling facility cost after tax deduction (high)	$86,568
CRF (10% DR, 20-yr life)	0.117
State Retail excise tax	4.17%

INPUTS FOR ALCOHOL SCENARIOS

(Note: some information is used in more than one scenario.)

M1a	M1a	M1a	M1a	M1a	M1a	M1a	M1a	M1a	M1a	M1a
M1a	COST	ASSUMPTIONS AND FUEL COST ELEMENTS				COST ESTIMATES		COST ESTIMATES		M1a
M1a	CATEGORY					low	high	low	high	M1a
M1a	Parameters	Annual demand/supply (1000 gal M85)				7	7	200	200	M1a
M1a		Annual demand/supply M100 (1000 gal)				6	6	170	170	M1a
M1a		Shipping container (tank) size (gal)				6100	6100	6100	6100	M1a
M1a		Number of tanks shipped per year				1.0	1.0	28.0	28.0	M1a
M1a		Actual volume imported via containers (1000 gal				6.1	6.1	170.8	170.8	M1a
M1a		Number of refueling locations				1	1	1	1	M1a
M1a		Annual throughput per station (1000 gal M85)				7.18	7.18	201	201	M1a
M1a	Mainland pr	Price loaded onto ship (/gal M100)								M1a
M1a				CEC methanol reserve price		$0.42	$0.50	$0.42	$0.50	M1a
M1a	Shipping	Shipping cost (/gal M100):								M1a
M1a		Shipping cost from $4000 to $6000 per container				$0.66	$0.98	$0.66	$0.98	M1a
M1a		Total landed cost (/gal M100)				$1.08	$1.48	$1.08	$1.48	M1a
M1a	Truck	Hauling from harbor to stations and transfer to station tank:								M1a
M1a	Transport of		Hauling (loaded rate/hr)			$75	$75	$75	$75	M1a
M1a	Containers to		Number of truck trips per station/ yea			1	1	33	33	M1a
M1a	Stations		Trip cost per truck			$200	$200	$200	$200	M1a
M1a		Trip cost per gallon (/gal M100)				$0.03	$0.03	$0.03	$0.03	M1a
M1a		Total cost/gal M100 to refueling station				$1.10	$1.51	$1.11	$1.52	M1a
M1a		Delivered cost/gal M100 with wholesale transacti				$1.11	$1.52	$1.11	$1.52	M1a
M1a	Blending	Labor and fuel cost associated with blending:								M1a
M1a			Gasoline price @ rack (/gal gasoline)			$0.89	$0.89	$0.89	$0.89	M1a
M1a			Gasoline tankwagon price (/gal gaso			$0.92	$0.92	$0.92	$0.92	M1a
M1a			Cost of 0.15 gal gasoline			$0.14	$0.14	$0.14	$0.14	M1a
M1a			Savings of -.15 gal of alcohol			($0.17)	($0.23)	($0.17)	($0.23)	M1a
M1a			Labor cost (/year)			$75	$75	$2,475	$2,475	M1a
M1a		Total cost of M85 fuel (/gal M85)				$1.09	$1.44	$1.10	$1.45	M1a
M1a	Retailing	Total retail margin with new methanol facility installation:								M1a
M1a			Total cost (materials and installation)			$0	$103,000	$0	$103,000	M1a
M1a			Cost after tax deduction (28.65% tota			$0	$86,568	$0	$86,568	M1a
M1a			CRF (10% DR, 20-yr life)			0.117	0.117	0.117	0.117	M1a
M1a			Annual throughput M85 (1000 gal)			7.18	7.18	201	201	M1a
M1a			Annualized capital cost (/gal M85)			$0.00	$1.42	$0.00	$0.05	M1a
M1a			Transaction Cost Margin			$0.03	$0.03	$0.03	$0.03	M1a
M1a			Additional Cost Margin (see Appendi			$0.03	$0.03	$0.03	$0.03	M1a
M1a		Total Retail Margin				$0.06	$1.48	$0.06	$0.11	M1a
M1a		Total cost of M85 fuel at the pump (/gal M85)				$1.15	$2.92	$1.16	$1.56	M1a
M1a	Fuel taxes	Federal, state, and local fuel taxes:								M1a
M1a			Federal excise tax (/gal)			$0.07	$0.07	$0.07	$0.07	M1a
M1a			State fuel tax (/gal)			$0.16	$0.16	$0.16	$0.16	M1a
M1a			City and County of Honolulu fuel tax (			$0.17	$0.17	$0.17	$0.17	M1a
M1a			Federal energy tax (/gal)			$0.04	$0.04	$0.04	$0.04	M1a
M1a		Total taxes (/gal M85)				$0.44	$0.44	$0.44	$0.44	M1a
M1a		Total cost after fuel taxes at station (/gal M85)				$1.59	$3.36	$1.60	$2.00	M1a
M1a	Sales tax		Plus state excise tax on retail sales			$1.64	$3.48	$1.64	$2.06	M1a
M1a										M1a
M1a	**Total cost of M85 fuel at the pump(/gal gasoline equivale**					**$2.86**	**$6.06**	**$2.87**	**$3.59**	M1a
M1a	Notes:									M1a
M1a	1. Station throughput per year assumed to be greater than one 6100 gallon tank of M100.									M1a
M1a	Number of stations kept at one until an annual throughput of about 200,000 gallons									M1a
M1a	M1a	M1a	M1a	M1a	M1a	M1a	M1a	M1a	M1a	M1a

.nwtx	M1a.nwtx	M1a.nwtx	M1a.nwtx	M1a.nwtx	M1a.nwtx	M1a.nwtx	M1a.nwtx	M1a.nwtx	M1a.nwtx	M1a.n
.nwtx	COST	ASSUMPTIONS AND FUEL COST ELEMENTS				COST ESTIMATES		COST ESTIMATES		M1a.n
.nwtx	CATEGORY					low	high	low	high	M1a.n
.nwtx	Parameters	Annual demand/supply (1000 gal M85)				7.00	7.00	200.00	200.00	M1a.n
.nwtx		Annual demand/supply M100 (1000 gal)				6.00	6.00	170.00	170.00	M1a.n
.nwtx		Shipping container (tank) size (gal)				6100.00	6100.00	6100.00	6100.00	M1a.n
.nwtx		Number of tanks shipped per year				1.00	1.00	28.00	28.00	M1a.n
.nwtx		Actual volume imported via containers (1000 gal				6.10	6.10	170.80	170.80	M1a.n
.nwtx		Number of refueling locations				1.00	1.00	1.00	1.00	M1a.n
.nwtx		Annual throughput per station (1000 gal M85)				7.18	7.18	200.94	200.94	M1a.n
.nwtx	Mainland pr	Price loaded onto ship (/gal M100)								M1a.n
.nwtx			CEC methanol reserve price			0.42	0.50	0.42	0.50	M1a.n
.nwtx	Shipping	Shipping cost (/gal M100):								M1a.n
.nwtx		Shipping cost from $4000 to $6000 per container				0.66	0.98	0.66	0.98	M1a.n
.nwtx		Total landed cost (/gal M100)				1.08	1.48	1.08	1.48	M1a.n
.nwtx	Truck	Hauling from harbor to stations and transfer to station tank:								M1a.n
.nwtx	Transport of		Hauling (loaded rate/hr)			75.00	75.00	75.00	75.00	M1a.n
.nwtx	Containers to		Number of truck trips per station/ yea			1.00	1.00	33.00	33.00	M1a.n
.nwtx	Stations		Trip cost per truck			200.00	200.00	200.00	200.00	M1a.n
.nwtx		Trip cost per gallon (/gal M100)				0.03	0.03	0.03	0.03	M1a.n
.nwtx		Total cost/gal M100 to refueling station				1.10	1.51	1.11	1.52	M1a.n
.nwtx		Delivered cost/gal M100 with wholesale transactic				1.11	1.52	1.11	1.52	M1a.n
.nwtx	Blending	Labor and fuel cost associated with blending:								M1a.n
.nwtx			Gasoline price @ rack (/gal gasoline)			0.89	0.89	0.89	0.89	M1a.n
.nwtx			Gasoline tankwagon price (/gal gasol			0.92	0.92	0.92	0.92	M1a.n
.nwtx			Cost of 0.15 gal gasoline			0.14	0.14	0.14	0.14	M1a.n
.nwtx			Savings of -.15 gal of alcohol			-0.17	-0.23	-0.17	-0.23	M1a.n
.nwtx			Labor cost (/year)			75.00	75.00	2475.00	2475.00	M1a.n
.nwtx		Total cost of M85 fuel (/gal M85)				1.09	1.44	1.10	1.45	M1a.n
.nwtx	Retailing	Total retail margin with new methanol facility installation:								M1a.n
.nwtx			Total cost (materials and installation)			0.00	103000.00	0.00	103000.00	M1a.n
.nwtx			Cost after tax deduction (28.65% tota			0.00	86567.55	0.00	86567.55	M1a.n
.nwtx			CRF (10% DR, 20-yr life)			0.12	0.12	0.12	0.12	M1a.n
.nwtx			Annual throughput M85 (1000 gal)			7.18	7.18	200.94	200.94	M1a.n
.nwtx			Annualized capital cost (/gal M85)			0.00	1.42	0.00	0.05	M1a.n
.nwtx			Transaction Cost Margin			0.03	0.03	0.03	0.03	M1a.n
.nwtx			Additional Cost Margin (see Appendi			0.03	0.03	0.03	0.03	M1a.n
.nwtx		Total Retail Margin				0.06	1.48	0.06	0.11	M1a.n
.nwtx		Total cost of M85 fuel at the pump (/gal M85)				1.15	2.92	1.16	1.56	M1a.n
.nwtx	Fuel taxes	Federal, state, and local fuel taxes:								M1a.n
.nwtx			Federal excise tax (/gal)			0.07	0.07	0.07	0.07	M1a.n
.nwtx			State fuel tax (/gal)			0.08	0.08	0.08	0.08	M1a.n
.nwtx			City and County of Honolulu fuel tax			0.09	0.09	0.09	0.09	M1a.n
.nwtx			Federal energy tax (/gal)			0.04	0.04	0.04	0.04	M1a.n
.nwtx		Total taxes (/gal M85)				0.28	0.28	0.28	0.28	M1a.n
.nwtx										M1a.nv
.nwtx		Total cost after fuel taxes at station (/gal M85)				1.43	3.20	1.44	1.84	M1a.nv
.nwtx	Sales tax		Plus state excise tax on retail sales			1.48	3.32	1.49	1.91	M1a.nv
.nwtx										M1a.nv
.nwtx	Total cost of M85 fuel at the pump(/gal gasoline equivalent)					2.59	5.79	2.60	3.32	M1a.nv
.nwtx	M1a.nwtx	M1a.nwtx	M1a.nwtx	M1a.nwtx	M1a.nwtx	M1a.nwtx	M1a.nwtx	M1a.nwtx	M1a.nwtx	M1a.nv

Scenario M1b	
Methanol (714000 and 1275000 gpy, parcel tanker) Shipped from Mainland, Sold as M85 (M1b)	
Annual demand/supply (1000 gal M85)	840
Annual demand/supply (1000 gal M85)	1,500
Shipping cost /metric ton (low)	$48
Shipping cost/metric ton (high)	$55
CEC methanol reserve price (low)	$0.42
CEC methanol reserve price(high)	$0.50
Target (minimum) throughput per station (1000 gal)	200
Terminal (Barbers Pt.) cost/gal (1)(low)	$1.01
Terminal (Barbers Pt.) cost/gal (1)(high)	$1.43
Terminal (Barbers Pt.) cost/gal (2)(low)	$0.56
Terminal (Barbers Pt.) cost/gal (2)(high)	$0.80
Tank truck capacity (gal)	8,500

INPUTS FOR ALCOHOL SCENARIOS

(Note: some information is used in more than one scenario.)

M1b	M1b	M1b	M1b	M1b	M1b	M1b	M1b	M1b	M1b	M1b
M1b	COST	ASSUMPTIONS AND FUEL COST ELEMENTS				COST ESTIMATES		COST ESTIMATES		M1b
M1b	CATEGORY					low	high	low	high	M1b
M1b	Parameters	Annual demand/supply (1000 gal M85)				**840**	**840**	**1500**	**1500**	M1b
M1b		Annual demand/supply M100 (1000 gal)				714	714	1275	1275	M1b
M1b		Number of stations				4	4	6	6	M1b
M1b		Annual throughput per station (1000 gal M85)				210	210	250	250	M1b
M1b	Mainland pr	Price loaded onto ship (/gal M100)								M1b
M1b			CEC Methanol Reserve Price			$0.42	$0.50	$0.42	$0.50	M1b
M1b										M1b
M1b	Shipping	Shipping cost (/gal M100):								M1b
M1b	Gallons M100 per metric ton			346		$0.14	$0.16	$0.14	$0.16	M1b
M1b		Total landed cost (/gal M100)				$0.56	$0.66	$0.56	$0.66	M1b
M1b	Terminalling	Terminalling + Trucking:								M1b
M1b	Trucking from		Terminal cost (/gal M100)			$1.01	$1.43	$0.56	$0.80	M1b
M1b	Rack to Station		Trucking cost (/gal M85)			$0.05	$0.05	$0.05	$0.05	M1b
M1b	Blending	Labor and fuel cost associated with blending:								M1b
M1b			Gasoline price @ rack (/gal gasoline			$0.89	$0.89	$0.89	$0.89	M1b
M1b			Gasoline tankwagon price (/gal gasol			$0.92	$0.92	$0.92	$0.92	M1b
M1b			Cost of 0.15 gal gasoline			$0.14	$0.14	$0.14	$0.14	M1b
M1b			Savings of -.15 gal of alcohol			($0.24)	($0.32)	($0.18)	($0.23)	M1b
M1b		Total cost of methanol to refueling station (/gal M				$1.51	$1.95	$1.13	$1.42	M1b
M1b		Delivered cost with wholesale transaction tax (/g				$1.51	$1.96	$1.14	$1.42	M1b
M1b	Retailing	Total retail margin with new methanol facility installation:								M1b
M1b			Total cost (materials and installation)			$0	$103,000	$0	$103,000	M1b
M1b			Cost after tax deduction (28.65% tota			$0	$86,568	$0	$86,568	M1b
M1b			CRF (10% DR, 20-yr life)			0.117	0.117	0.117	0.117	M1b
M1b			Annual throughput M85 (1000 gal)			210	210	250	250	M1b
M1b			Annualized capital cost (/gal M85)			$0.00	$0.05	$0.00	$0.04	M1b
M1b			Transaction Cost Margin			$0.03	$0.03	$0.03	$0.03	M1b
M1b			Additional Cost Margin (see Appendi			$0.03	$0.03	$0.03	$0.03	M1b
M1b		Total Retail Margin				$0.06	$0.11	$0.06	$0.10	M1b
M1b		Total cost of M85 fuel at the pump (/gal M85)				$1.57	$2.06	$1.19	$1.52	M1b
M1b	Fuel taxes	Federal, state, and local fuel taxes:								M1b
M1b			Federal excise tax (/gal)			$0.07	$0.07	$0.07	$0.07	M1b
M1b			State fuel tax (/gal)			$0.16	$0.16	$0.16	$0.16	M1b
M1b			City and County of Honolulu fuel tax			$0.17	$0.17	$0.17	$0.17	M1b
M1b			Federal energy tax (/gal)			$0.04	$0.04	$0.04	$0.04	M1b
M1b		Total taxes (/gal M85)				$0.44	$0.44	$0.44	$0.44	M1b
M1b		Total cost after fuel taxes at station (/gal M85)				$2.01	$2.50	$1.63	$1.96	M1b
M1b	Sales tax		Plus state excise tax on retail sales			$2.07	$2.58	$1.68	$2.02	M1b
M1b										M1b
M1b	**Total cost of M85 fuel at the pump(/gal gasoline equivale**					**$3.61**	**$4.50**	**$2.93**	**$3.52**	M1b
M1b										M1b
M1b	M1b	M1b	M1b	M1b	M1b	M1b	M1b	M1b	M1b	M1b

b.nwtx	M1b.nwtx	M1b.nwtx	M1b.nwtx	M1b.nwtx	M1b.nwtx	M1b.nwtx	M1b.nwtx	M1b.nwtx	M1b.nwtx	M1b.
b.nwtx	COST	ASSUMPTIONS AND FUEL COST ELEMENTS				COST ESTIMATES		COST ESTIMATES		M1b.
b.nwtx	CATEGORY					low	high	low	high	M1b.
b.nwtx	Parameters	Annual demand/supply (1000 gal M85)				840.00	840.00	1500.00	1500.00	M1b.
b.nwtx		Annual demand/supply M100 (1000 gal)				714.00	714.00	1275.00	1275.00	M1b.
b.nwtx		Number of stations				4.00	4.00	6.00	6.00	M1b.
b.nwtx		Annual throughput per station (1000 gal M85)				210.00	210.00	250.00	250.00	M1b.
b.nwtx	Mainland pr	Price loaded onto ship (/gal M100)								M1b.
b.nwtx			CEC Methanol Reserve Price			0.42	0.50	0.42	0.50	M1b.
b.nwtx										M1b.
b.nwtx	Shipping	Shipping cost (/gal M100):								M1b.
b.nwtx			Gallons M1	346.02		0.14	0.16	0.14	0.16	M1b.
b.nwtx		Total landed cost (/gal M100)				0.56	0.66	0.56	0.66	M1b.
b.nwtx	Terminallin	Terminalling + Trucking:								M1b.
b.nwtx	Trucking from		Terminal cost (/gal M100)			1.01	1.43	0.56	0.80	M1b.
b.nwtx	Rack to Station		Trucking cost (/gal M85)			0.05	0.05	0.05	0.05	M1b.
b.nwtx	Blending	Labor and fuel cost associated with blending:								M1b.
b.nwtx			Gasoline price @ rack (/gal gasoline			0.89	0.89	0.89	0.89	M1b.
b.nwtx			Gasoline tankwagon price (/gal gasol			0.92	0.92	0.92	0.92	M1b.
b.nwtx			Cost of 0.15 gal gasoline			0.14	0.14	0.14	0.14	M1b.
b.nwtx			Savings of -.15 gal of alcohol			-0.24	-0.32	-0.18	-0.23	M1b.
b.nwtx		Total cost of methanol to refueling station (/gal M				1.51	1.95	1.13	1.42	M1b.
b.nwtx		Delivered cost with wholesale transaction tax (/g				1.51	1.96	1.14	1.42	M1b.
b.nwtx	Retailing	Total retail margin with new methanol facility installation:								M1b.
b.nwtx			Total cost (materials and installation)			0.00	103000.00	0.00	103000.00	M1b.
b.nwtx			Cost after tax deduction (28.65% tot			0.00	86567.55	0.00	86567.55	M1b.
b.nwtx			CRF (10% DR, 20-yr life)			0.12	0.12	0.12	0.12	M1b.
b.nwtx			Annual throughput M85 (1000 gal)			210.00	210.00	250.00	250.00	M1b.
b.nwtx			Annualized capital cost (/gal M85)			0.00	0.05	0.00	0.04	M1b.
b.nwtx			Transaction Cost Margin			0.03	0.03	0.03	0.03	M1b.
b.nwtx			Additional Cost Margin (see Appendi			0.03	0.03	0.03	0.03	M1b.
b.nwtx		Total Retail Margin				0.06	0.11	0.06	0.10	M1b.
b.nwtx		Total cost of M85 fuel at the pump (/gal M85)				1.57	2.06	1.19	1.52	M1b.
b.nwtx	Fuel taxes	Federal, state, and local fuel taxes:								M1b.
b.nwtx			Federal excise tax (/gal)			0.07	0.07	0.07	0.07	M1b.
b.nwtx			State fuel tax (/gal)			0.08	0.08	0.08	0.08	M1b.
b.nwtx			City and County of Honolulu fuel tax (			0.09	0.09	0.09	0.09	M1b.
b.nwtx			Federal energy tax (/gal)			0.04	0.04	0.04	0.04	M1b.
b.nwtx		Total taxes (/gal M85)				0.28	0.28	0.28	0.28	M1b.
b.nwtx										M1b.
b.nwtx		Total cost after fuel taxes at station (/gal M85)				1.85	2.34	1.47	1.80	M1b.
b.nwtx	Sales tax		Plus state excise tax on retail sales			1.92	2.43	1.52	1.86	M1b.
b.nwtx										M1b.
b.nwtx	Total cost of M85 fuel at the pump(/gal gasoline equivalent)					3.34	4.23	2.66	3.25	M1b.
b.nwtx	M1b.nwtx	M1b.nwtx	M1b.nwtx	M1b.nwtx	M1b.nwtx	M1b.nwtx	M1b.nwtx	M1b.nwtx	M1b.nwtx	M1b.

Scenario M2a	
Methanol (10, 59, and 184 million gpy) from Banagrass on Oahu, Sold as M85 (M2a)	
Annual demand/supply (10^6 gpy M100) (1)	10
Assumed plant size (mgpy) (1)	10
Annual demand/supply (10^6 gpy M100) (2)	59
Assumed plant size (mgpy) (2)	59
Annual demand/supply (10^6 gpy M100) (3)	184
Assumed plant size (mgpy) (3)	92
Feedstock type	Banagrass
Number of Refueling Stations (1)	59
Number of Refueling Stations (2)	347
Number of Refueling Stations (3)	400
Feedstock price/ton (low)	$52.19
Feedstock price/ton (high)	$84.76
Plant Gate FOB Price (/gal M100) (1)(low)	$0.99
Plant Gate FOB Price (/gal M100) (1)(high)	$1.53
Plant Gate FOB Price (/gal M100) (2)(low)	$0.74
Plant Gate FOB Price (/gal M100) (2)(high)	$1.19
Plant Gate FOB Price (/gal M100) (3)(low)	$0.70
Plant Gate FOB Price (/gal M100) (3)(high)	$1.13
Plant assumed profitable? (1)(low)	yes
Plant assumed profitable? (1)(high)	no
Plant assumed profitable? (2)(low)	yes
Plant assumed profitable? (2)(high)	no
Plant assumed profitable? (3)(low)	yes
Plant assumed profitable? (3)(high)	no
Business income tax rate	35%
Federal tax credit for alcohol from biomass	$0.54
Number of stations serviced per truck	1
Assumed tankwagon time (hrs)	3
State retail excise tax on biomass alcohol	0%

INPUTS FOR ALCOHOL SCENARIOS

(Note: some information is used in more than one scenario.)

M2a M2a M2a M2a M2a M2a M2a M2a M2a M2a M2a

M2a	COST	ASSUMPTIONS AND FUEL COST ELEMENTS	COST ESTIMATES		COST ESTIMATES		M2a
M2a	CATEGORY		low	high	low	high	M2a
M2a	Parameters	Annual demand/supply (10^6 gpy M100)	**10**	**10**	**184**	**184**	M2a
M2a		Assumed plant size (mgpy)	10	10	92	92	M2a
M2a		Feedstock type	Banagrass	Banagrass	Banagrass	Banagrass	M2a
M2a		Number of refueling stations	59	59	400	400	M2a
M2a		Annual throughput per station (1000 gal M85)	200	200	541	541	M2a
M2a		Annual demand/supply (10^6 gpy M85)	12	12	216	216	M2a
M2a	Plant gate p	Feedstock price (/ton)	$52	$85	$52	$85	M2a
M2a		Plant Gate FOB Price (/gal M100)	$0.99	$1.53	$0.70	$1.13	M2a
M2a		Company assumed profitable?	yes	no	yes	no	M2a
M2a		Federal business income tax rate	35%	35%	35%	35%	M2a
M2a		Biomass alcohol fuel credit after taxes (/gal M100	$0.00	$0.00	$0.00	$0.00	M2a
M2a		Plant gate price after tax credit	$0.99	$1.53	$0.70	$1.13	M2a
M2a		Plus wholesale transaction tax	$0.99	$1.53	$0.70	$1.13	M2a
M2a	Truck	Tank truck to terminal, then to plant, then to station					M2a
M2a	Transport to	Tankwagon (loaded rate/hr)	$150	$150	$150	$150	M2a
M2a	Stations	Number of stations serviced per truc	1	1	1	1	M2a
M2a		Assumed time to take on gasoline at	-	-	-	-	M2a
M2a		methanol at plant and unload at station (hrs)	3	3	3	3	M2a
M2a		Trip cost per truck	$450	$450	$450	$450	M2a
M2a		Trip cost per gallon M85	$0.05	$0.05	$0.05	$0.05	M2a
M2a	Blending	Fuel cost associated with in-truck blending:					M2a
M2a		Gasoline price @ rack (/gal gasoline)	$0.89	$0.89	$0.89	$0.89	M2a
M2a		Cost of 0.15 gal gasoline	$0.13	$0.13	$0.13	$0.13	M2a
M2a		Savings of -.15 gal of alcohol	($0.15)	($0.23)	($0.10)	($0.17)	M2a
M2a		Total cost of M85 fuel delivered to refueling statio	$1.03	$1.49	$0.78	$1.15	M2a
M2a		Delivered cost with wholesale transaction tax (/g N	$1.04	$1.50	$0.78	$1.16	M2a
M2a	Retailing	Total retail margin with new methanol facility installation:					M2a
M2a		Total cost (materials and installation)	$0	$103,000	$0	$103,000	M2a
M2a		Cost after tax deduction (28.65% tota	$0	$86,568	$0	$86,568	M2a
M2a		CRF (10% DR, 20 yr life)	0.117	0.117	0.117	0.117	M2a
M2a		Annual throughput M85 (1000 gal)	200	200	541	541	M2a
M2a		Annualized capital cost (/gal)	$0.00	$0.05	$0.00	$0.02	M2a
M2a		Transaction Cost Margin	$0.03	$0.03	$0.03	$0.03	M2a
M2a		Additional Cost Margin	$0.03	$0.03	$0.03	$0.03	M2a
M2a		Total Retail Margin	$0.06	$0.11	$0.06	$0.08	M2a
M2a		Total cost of M85 fuel at the pump (/gal M85)	$1.09	$1.60	$0.84	$1.23	M2a
M2a	Fuel taxes	Federal, state, and local fuel taxes:					M2a
M2a		Federal excise tax (/gal)	$0.08	$0.08	$0.08	$0.08	M2a
M2a		State fuel tax (/gal)	$0.16	$0.16	$0.16	$0.16	M2a
M2a		City and County of Honolulu fuel tax (	$0.17	$0.17	$0.17	$0.17	M2a
M2a		Federal energy tax (/gal)	$0.04	$0.04	$0.04	$0.04	M2a
M2a		Total taxes (/gal M85)	$0.45	$0.45	$0.45	$0.45	M2a
M2a		Total cost after fuel taxes at station (/gal M85)	$1.54	$2.05	$1.29	$1.68	M2a
M2a	Sales tax	Plus state excise tax on retail sales	$1.54	$2.05	$1.29	$1.68	M2a
M2a							M2a
M2a	**Total cost of M85 fuel at the pump(/gal gasoline equivale**		**$2.68**	**$3.57**	**$2.25**	**$2.92**	M2a
M2a							M2a

M2a M2a M2a M2a M2a M2a M2a M2a M2a M2a M2a

.nwtx	M2a.nwtx	M2a.nwtx	M2a.nwtx	M2a.nwtx	M2a.nwtx	M2a.nwtx	M2a.nwtx	M2a.nwtx	M2a.nwtx	M2a.n
.nwtx	COST	ASSUMPTIONS AND FUEL COST ELEMENTS				COST ESTIMATES		COST ESTIMATES		M2a.n
.nwtx	CATEGORY					low	high	low	high	M2a.n
.nwtx	Parameters	Annual demand/supply (10^6 gpy M100)				10.00	10.00	184.00	184.00	M2a.n
.nwtx		Assumed plant size (mgpy)				10.00	10.00	92.00	92.00	M2a.n
.nwtx		Feedstock type				Banagrass	Banagrass	Banagrass	Banagrass	M2a.n
.nwtx		Number of refueling stations				58.82	58.82	400.00	400.00	M2a.n
.nwtx		Annual throughput per station (1000 gal M85)				200.00	200.00	541.18	541.18	M2a.n
.nwtx		Annual demand/supply (10^6 gpy M85)				11.76	11.76	216.47	216.47	M2a.n
.nwtx	Plant gate p	Feedstock price (/ton)				52.19	84.76	52.19	84.76	M2a.n
.nwtx		Plant Gate FOB Price (/gal M100)				0.99	1.53	0.70	1.13	M2a.n
.nwtx		Company assumed profitable?				yes	no	yes	no	M2a.n
.nwtx		Federal business income tax rate				0.35	0.35	0.35	0.35	M2a.n
.nwtx		Biomass alcohol fuel credit after taxes (/gal M100				0.00	0.00	0.00	0.00	M2a.n
.nwtx		Plant gate price after tax credit				0.99	1.53	0.70	1.13	M2a.n
.nwtx		Plus wholesale transaction tax				0.99	1.53	0.70	1.13	M2a.n
.nwtx	Truck	Tank truck to terminal, then to plant, then to station								M2a.n
.nwtx	Transport to		Tankwagon (loaded rate/hr)			150.00	150.00	150.00	150.00	M2a.n
.nwtx	Stations		Number of stations serviced per truc			1.00	1.00	1.00	1.00	M2a.n
.nwtx			Assumed time to take on gasoline at			-	-	-	-	M2a.n
.nwtx					methanol a	3.00	3.00	3.00	3.00	M2a.n
.nwtx			Trip cost per truck			450.00	450.00	450.00	450.00	M2a.n
.nwtx		Trip cost per gallon M85				0.05	0.05	0.05	0.05	M2a.n
.nwtx	Blending	Fuel cost associated with in-truck blending:								M2a.n
.nwtx			Gasoline price @ rack (/gal gasoline)			0.89	0.89	0.89	0.89	M2a.n
.nwtx			Cost of 0.15 gal gasoline			0.13	0.13	0.13	0.13	M2a.n
.nwtx			Savings of -.15 gal of alcohol			-0.15	-0.23	-0.10	-0.17	M2a.n
.nwtx		Total cost of M85 fuel delivered to refueling statio				1.03	1.49	0.78	1.15	M2a.n
.nwtx		Delivered cost with wholesale transaction tax (/g				1.04	1.50	0.78	1.16	M2a.n
.nwtx	Retailing	Total retail margin with new methanol facility installation:								M2a.n
.nwtx			Total cost (materials and installation)			0.00	103000.00	0.00	103000.00	M2a.n
.nwtx			Cost after tax deduction (28.65% tot			0.00	86567.55	0.00	86567.55	M2a.n
.nwtx			CRF (10% DR, 20 yr life)			0.12	0.12	0.12	0.12	M2a.n
.nwtx			Annual throughput M85 (1000 gal)			200.00	200.00	541.18	541.18	M2a.n
.nwtx			Annualized capital cost (/gal)			0.00	0.05	0.00	0.02	M2a.n
.nwtx			Transaction Cost Margin			0.03	0.03	0.03	0.03	M2a.n
.nwtx			Additional Cost Margin			0.03	0.03	0.03	0.03	M2a.n
.nwtx		Total Retail Margin				0.06	0.11	0.06	0.08	M2a.n
.nwtx		Total cost of M85 fuel at the pump (/gal M85)				1.09	1.60	0.84	1.23	M2a.n
.nwtx	Fuel taxes	Federal, state, and local fuel taxes:								M2a.n
.nwtx			Federal excise tax (/gal)			0.08	0.08	0.08	0.08	M2a.n
.nwtx			State fuel tax (/gal)			0.08	0.08	0.08	0.08	M2a.n
.nwtx			City and County of Honolulu fuel tax			0.09	0.09	0.09	0.09	M2a.n
.nwtx			Federal energy tax (/gal)			0.04	0.04	0.04	0.04	M2a.n
.nwtx		Total taxes (/gal M85)				0.29	0.29	0.29	0.29	M2a.n
.nwtx										M2a.n
.nwtx		Total cost after fuel taxes at station (/gal M85)				1.38	1.89	1.13	1.52	M2a.n
.nwtx	Sales tax	Plus state excise tax on retail sales				1.38	1.89	1.13	1.52	M2a.n
.nwtx										M2a.n
.nwtx	Total cost of M85 fuel at the pump(/gal gasoline equivalent)					2.41	3.30	1.98	2.65	M2a.n
.nwtx	M2a.nwtx	M2a.nwtx	M2a.nwtx	M2a.nwtx	M2a.nwtx	M2a.nwtx	M2a.nwtx	M2a.nwtx	M2a.nwtx	M2a.n

M2a	M2a	M2a	M2a
M2a	COST ESTIMATES		M2a
M2a	low	high	M2a
M2a	**59**	**59**	M2a
M2a	59	59	M2a
M2a	Banagrass	Banagrass	M2a
M2a	400	400	M2a
M2a	174	174	M2a
M2a	69	69	M2a
M2a	$52	$85	M2a
M2a	$0.74	$1.19	M2a
M2a	yes	no	M2a
M2a	35%	35%	M2a
M2a	$0.26	$0.00	M2a
M2a	$0.48	$1.19	M2a
M2a	$0.49	$1.20	M2a
M2a			M2a
M2a	$150	$150	M2a
M2a	1.000	1.000	M2a
M2a	-	-	M2a
M2a	3	3	M2a
M2a	$450	$450	M2a
M2a	$0.05	$0.05	M2a
M2a			M2a
M2a	$0.89	$0.89	M2a
M2a	$0.13	$0.13	M2a
M2a	($0.11)	($0.18)	M2a
M2a	$0.56	$1.20	M2a
M2a	$0.56	$1.21	M2a
M2a			M2a
M2a	$0	$103,000	M2a
M2a	$0	$86,568	M2a
M2a	0.117	0.117	M2a
M2a	174	174	M2a
M2a	$0.00	$0.06	M2a
M2a	$0.03	$0.03	M2a
M2a	$0.03	$0.03	M2a
M2a	$0.06	$0.12	M2a
M2a	$0.62	$1.32	M2a
M2a			M2a
M2a	$0.08	$0.08	M2a
M2a	$0.16	$0.16	M2a
M2a	$0.17	$0.17	M2a
M2a	$0.04	$0.04	M2a
M2a	$0.45	$0.45	M2a
M2a	$1.07	$1.77	M2a
M2a	$1.07	$1.77	M2a
M2a			M2a
M2a	**$1.86**	**$3.09**	M2a
M2a			M2a
M2a	M2a	M2a	M2a

.nwtx	M2a.nwtx	M2a.nwtx M2a.nwtx M2a.nwtx M2a.nwtx	M2a.nwtx	M2a.nwtx	M2a.nwtx	M2a.nwtx	M2a.n
.nwtx	COST	ASSUMPTIONS AND FUEL COST ELEMENTS	COST ESTIMATES		COST ESTIMATES		M2a.n
.nwtx	CATEGORY		low	high	low	high	M2a.n
.nwtx	Parameters	Annual demand/supply (10^6 gpy M100)	10.00	10.00	184.00	184.00	M2a.n
.nwtx		Assumed plant size (mgpy)	10.00	10.00	92.00	92.00	M2a.n
.nwtx		Feedstock type	Banagrass	Banagrass	Banagrass	Banagrass	M2a.n
.nwtx		Number of refueling stations	58.82	58.82	400.00	400.00	M2a.n
.nwtx		Annual throughput per station (1000 gal M85)	200.00	200.00	541.18	541.18	M2a.n
.nwtx		Annual demand/supply (10^6 gpy M85)	11.76	11.76	216.47	216.47	M2a.n
.nwtx	Plant gate p	Feedstock price (/ton)	52.19	84.76	52.19	84.76	M2a.n
.nwtx		Plant Gate FOB Price (/gal M100)	0.99	1.53	0.70	1.13	M2a.n
.nwtx		Company assumed profitable?	yes	no	yes	no	M2a.n
.nwtx		Federal business income tax rate	0.35	0.35	0.35	0.35	M2a.n
.nwtx		Biomass alcohol fuel credit after taxes (/gal M100	0.00	0.00	0.00	0.00	M2a.n
.nwtx		Plant gate price after tax credit	0.99	1.53	0.70	1.13	M2a.n
.nwtx		Plus wholesale transaction tax	0.99	1.53	0.70	1.13	M2a.n
.nwtx	Truck	Tank truck to terminal, then to plant, then to station					M2a.n
.nwtx	Transport to	Tankwagon (loaded rate/hr)	150.00	150.00	150.00	150.00	M2a.n
.nwtx	Stations	Number of stations serviced per trucl	1.00	1.00	1.00	1.00	M2a.n
.nwtx		Assumed time to take on gasoline at	-	-	-	-	M2a.n
.nwtx		methanol a	3.00	3.00	3.00	3.00	M2a.n
.nwtx		Trip cost per truck	450.00	450.00	450.00	450.00	M2a.n
.nwtx		Trip cost per gallon M85	0.05	0.05	0.05	0.05	M2a.n
.nwtx	Blending	Fuel cost associated with in-truck blending:					M2a.n
.nwtx		Gasoline price @ rack (/gal gasoline	0.89	0.89	0.89	0.89	M2a.n
.nwtx		Cost of 0.15 gal gasoline	0.13	0.13	0.13	0.13	M2a.n
.nwtx		Savings of -.15 gal of alcohol	-0.15	-0.23	-0.10	-0.17	M2a.n
.nwtx		Total cost of M85 fuel delivered to refueling statio	1.03	1.49	0.78	1.15	M2a.n
.nwtx		Delivered cost with wholesale transaction tax (/g	1.04	1.50	0.78	1.16	M2a.n
.nwtx	Retailing	Total retail margin with new methanol facility installation:					M2a.n
.nwtx		Total cost (materials and installation)	0.00	103000.00	0.00	103000.00	M2a.n
.nwtx		Cost after tax deduction (28.65% tot	0.00	86567.55	0.00	86567.55	M2a.n
.nwtx		CRF (10% DR, 20 yr life)	0.12	0.12	0.12	0.12	M2a.n
.nwtx		Annual throughput M85 (1000 gal)	200.00	200.00	541.18	541.18	M2a.n
.nwtx		Annualized capital cost (/gal)	0.00	0.05	0.00	0.02	M2a.n
.nwtx		Transaction Cost Margin	0.03	0.03	0.03	0.03	M2a.n
.nwtx		Additional Cost Margin	0.03	0.03	0.03	0.03	M2a.n
.nwtx		Total Retail Margin	0.06	0.11	0.06	0.08	M2a.n
.nwtx		Total cost of M85 fuel at the pump (/gal M85)	1.09	1.60	0.84	1.23	M2a.n
.nwtx	Fuel taxes	Federal, state, and local fuel taxes:					M2a.n
.nwtx		Federal excise tax (/gal)	0.08	0.08	0.08	0.08	M2a.n
.nwtx		State fuel tax (/gal)	0.08	0.08	0.08	0.08	M2a.n
.nwtx		City and County of Honolulu fuel tax	0.09	0.09	0.09	0.09	M2a.n
.nwtx		Federal energy tax (/gal)	0.04	0.04	0.04	0.04	M2a.n
.nwtx		Total taxes (/gal M85)	0.29	0.29	0.29	0.29	M2a.n
.nwtx							M2a.n
.nwtx		Total cost after fuel taxes at station (/gal M85)	1.38	1.89	1.13	1.52	M2a.n
.nwtx	Sales tax	Plus state excise tax on retail sales	1.38	1.89	1.13	1.52	M2a.n
.nwtx							M2a.n
.nwtx	Total cost of M85 fuel at the pump(/gal gasoline equivalent)		2.41	3.30	1.98	2.65	M2a.n
.nwtx	M2a.nwtx	M2a.nwtx M2a.nwtx M2a.nwtx M2a.nwtx	M2a.nwtx	M2a.nwtx	M2a.nwtx	M2a.nwtx	M2a.n

M2a.nwtx	M2a.nwtx	M2a.nwtx	M2a.nwtx
M2a.nwtx	COST ESTIMATES		M2a.nwtx
M2a.nwtx	low	high	M2a.nwtx
M2a.nwtx	59.00	59.00	M2a.nwtx
M2a.nwtx	59.00	59.00	M2a.nwtx
M2a.nwtx	Banagrass	Banagrass	M2a.nwtx
M2a.nwtx	400.00	400.00	M2a.nwtx
M2a.nwtx	173.53	173.53	M2a.nwtx
M2a.nwtx	69.41	69.41	M2a.nwtx
M2a.nwtx	52.19	84.76	M2a.nwtx
M2a.nwtx	0.74	1.19	M2a.nwtx
M2a.nwtx	yes	no	M2a.nwtx
M2a.nwtx	0.35	0.35	M2a.nwtx
M2a.nwtx	0.26	0.00	M2a.nwtx
M2a.nwtx	0.48	1.19	M2a.nwtx
M2a.nwtx	0.49	1.20	M2a.nwtx
M2a.nwtx	0.00	0.00	M2a.nwtx
M2a.nwtx	150.00	150.00	M2a.nwtx
M2a.nwtx	1.00	1.00	M2a.nwtx
M2a.nwtx	-	-	M2a.nwtx
M2a.nwtx	3.00	3.00	M2a.nwtx
M2a.nwtx	450.00	450.00	M2a.nwtx
M2a.nwtx	0.05	0.05	M2a.nwtx
M2a.nwtx			M2a.nwtx
M2a.nwtx	0.89	0.89	M2a.nwtx
M2a.nwtx	0.13	0.13	M2a.nwtx
M2a.nwtx	-0.11	-0.18	M2a.nwtx
M2a.nwtx	0.56	1.20	M2a.nwtx
M2a.nwtx	0.56	1.21	M2a.nwtx
M2a.nwtx			M2a.nwtx
M2a.nwtx	0.00	103000.00	M2a.nwtx
M2a.nwtx	0.00	86567.55	M2a.nwtx
M2a.nwtx	0.12	0.12	M2a.nwtx
M2a.nwtx	173.53	173.53	M2a.nwtx
M2a.nwtx	0.00	0.06	M2a.nwtx
M2a.nwtx	0.03	0.03	M2a.nwtx
M2a.nwtx	0.03	0.03	M2a.nwtx
M2a.nwtx	0.06	0.12	M2a.nwtx
M2a.nwtx	0.62	1.32	M2a.nwtx
M2a.nwtx			M2a.nwtx
M2a.nwtx	0.08	0.08	M2a.nwtx
M2a.nwtx	0.08	0.08	M2a.nwtx
M2a.nwtx	0.09	0.09	M2a.nwtx
M2a.nwtx	0.04	0.04	M2a.nwtx
M2a.nwtx	0.29	0.29	M2a.nwtx
M2a.nwtx			M2a.nwtx
M2a.nwtx	0.91	1.62	M2a.nwtx
M2a.nwtx	0.91	1.62	M2a.nwtx
M2a.nwtx			M2a.nwtx
M2a.nwtx	1.59	2.82	M2a.nwtx
M2a.nwtx	M2a.nwtx	M2a.nwtx	M2a.nwtx

Scenario M2b	
Methanol (1247 million gpy) from Coal on Oahu, Sold as M85 (M2b)	
Annual demand/supply (10^6 gpy M100) (1)	433
Assumed plant size (mgpy) (1)	1,247
Annual demand/supply (10^6 gpy M100) (2)	433
Assumed plant size (mgpy) (2)	1,247
Feedstock type	Coal
Number of Refueling Stations (1)	400
Number of Refueling Stations (2)	400
Feedstock price/ton (low)	$53.00
Feedstock price/ton (high)	$53.00
Plant Gate FOB Price (/gal M100) (Note 1) (1)	$0.67
Plant Gate FOB Price (/gal M100) (Note 1) (2)	$1.07
Number of stations serviced per truck	1
Assumed tankwagon time (hrs)	3

INPUTS FOR ALCOHOL SCENARIOS

(Note: some information is used in more than one scenario.)

M2b M2b M2b M2b M2b M2b M2b M2b M2b M2b M2b

M2b	COST CATEGORY	ASSUMPTIONS AND FUEL COST ELEMENTS	COST ESTIMATES low	COST ESTIMATES high	COST ESTIMATES low	COST ESTIMATES high	M2b
M2b	Parameters	Annual demand/supply (10^6 gpy M100)	433	433	433	433	M2b
M2b		Assumed plant size (mgpy)	1247	1247	1247	1247	M2b
M2b		Feedstock type	Coal	Coal	Coal	Coal	M2b
M2b		Number of refueling stations	400	400	400	400	M2b
M2b		Annual throughput per station (1000 gal M85)	1275	1275	1275	1275	M2b
M2b		Annual demand/supply (10^6 gpy M85)	510	510	510	510	M2b
M2b	Plant gate p	Feedstock price (/ton)	$53	$53	$53	$53	M2b
M2b		Plant Gate FOB Price (/gal M100) (Note 1)	$0.67	$0.67	$1.07	$1.07	M2b
M2b		Plus wholesale transaction tax	$0.67	$0.67	$1.08	$1.08	M2b
M2b	Truck	Tank truck to terminal, then to plant, then to station					M2b
M2b	Transport to	Loaded labor rate (/hr)	$150	$150	$150	$150	M2b
M2b	Stations	Number of stations serviced per truc	1	1	1	1	M2b
M2b		Assumed time to take on gasoline at	-	-	-	-	M2b
M2b		methanol at plant and unload at station (hrs)	3	3	3	3	M2b
M2b		Trip cost per truck	$450	$450	$450	$450	M2b
M2b		Trip cost per gallon M85	$0.05	$0.05	$0.05	$0.05	M2b
M2b	Blending	Fuel cost associated with in-truck blending:					M2b
M2b		Gasoline price @ rack (/gal gasoline)	$0.89	$0.89	$0.89	$0.89	M2b
M2b		Cost of 0.15 gal gasoline	$0.13	$0.13	$0.13	$0.13	M2b
M2b		Savings of -.15 gal of alcohol	($0.10)	($0.10)	($0.16)	($0.16)	M2b
M2b		Total cost of M85 fuel delivered to refueling statio	$0.76	$0.76	$1.10	$1.10	M2b
M2b		Delivered cost with wholesale transaction tax (/g M	$0.76	$0.76	$1.11	$1.11	M2b
M2b	Retailing	Total retail margin with new methanol facility installation:					M2b
M2b		Total cost (materials and installation)	$0	$103,000	$0	$103,000	M2b
M2b		Cost after tax deduction (28.65% tota	$0	$86,568	$0	$86,568	M2b
M2b		CRF (10% DR, 20 yr life)	0.117	0.117	0.117	0.117	M2b
M2b		Annual throughput M85 (1000 gal)	1275	1275	1275	1275	M2b
M2b		Annualized capital cost (/gal)	$0.00	$0.01	$0.00	$0.01	M2b
M2b		Transaction Cost Margin	$0.03	$0.03	$0.03	$0.03	M2b
M2b		Additional Cost Margin (see Appendi	$0.03	$0.03	$0.03	$0.03	M2b
M2b		Total Retail Margin	$0.06	$0.07	$0.06	$0.07	M2b
M2b		Total cost of M85 fuel at the pump (/gal M85)	$0.82	$0.83	$1.16	$1.17	M2b
M2b	Fuel taxes	Federal, state, and local fuel taxes:					M2b
M2b		Federal excise tax (/gal)	$0.08	$0.08	$0.08	$0.08	M2b
M2b		State fuel tax (/gal)	$0.16	$0.16	$0.16	$0.16	M2b
M2b		City and County of Honolulu fuel tax (	$0.17	$0.17	$0.17	$0.17	M2b
M2b		Federal energy tax (/gal)	$0.04	$0.04	$0.04	$0.04	M2b
M2b		Total taxes (/gal M85)	$0.45	$0.45	$0.45	$0.45	M2b
M2b		Total cost after fuel taxes at station (/gal M85)	$1.27	$1.28	$1.61	$1.62	M2b
M2b	Sales tax	Plus state excise tax on retail sales	$1.30	$1.31	$1.66	$1.67	M2b
M2b							M2b
M2b	**Total cost of M85 fuel at the pump(/gal gasoline equivale**		**$2.27**	**$2.28**	**$2.89**	**$2.90**	M2b
M2b	Notes:						M2b
M2b	1. Low plant gate price estimate assumes co-production of methanol and electricity from coal.						M2b
M2b	High price assumes only methanol produced.						M2b
M2b	2. For consistency with other scenarios, only potential demand/price for M85 on one island (Oahu) is considerec						M2b
M2b	Statewide, maximum demand for methanol for on-highway ground transportation (mgpy):						M2b
M2b	650 (equivalent to 85% of statewide 1992 on-highway demand for gasoline)						M2b
M2b	60 (equivalent to 100% of statewide 1992 on-highway demand for diesel)						M2b
M2b	710 million gallons per year.						M2b

M2b M2b M2b M2b M2b M2b M2b M2b M2b M2b M2b

b.nwtx	M2b.nwtx	M2b.nwtx	M2b.nwtx	M2b.nwtx	M2b.nwtx	M2b.nwtx	M2b.nwtx	M2b.nwtx	M2b.nwtx	M2b.n
b.nwtx	COST	ASSUMPTIONS AND FUEL COST ELEMENTS				COST ESTIMATES		COST ESTIMATES		M2b.n
b.nwtx	CATEGORY					low	high	low	high	M2b.n
b.nwtx	Parameters	Annual demand/supply (10^6 gpy M100)				433.49	433.49	433.49	433.49	M2b.n
b.nwtx		Assumed plant size (mgpy)				1247.00	1247.00	1247.00	1247.00	M2b.n
b.nwtx		Feedstock type				Coal	Coal	Coal	Coal	M2b.n
b.nwtx		Number of refueling stations				400.00	400.00	400.00	400.00	M2b.n
b.nwtx		Annual throughput per station (1000 gal M85)				1274.96	1274.96	1274.96	1274.96	M2b.n
b.nwtx		Annual demand/supply (10^6 gpy M85)				509.98	509.98	509.98	509.98	M2b.n
b.nwtx	Plant gate p	Feedstock price (/ton)				53.00	53.00	53.00	53.00	M2b.n
b.nwtx		Plant Gate FOB Price (/gal M100) (Note 1)				0.67	0.67	1.07	1.07	M2b.n
b.nwtx		Plus wholesale transaction tax				0.67	0.67	1.08	1.08	M2b.n
b.nwtx	Truck	Tank truck to terminal, then to plant, then to station								M2b.n
b.nwtx	Transport to		Loaded labor rate (/hr)			150.00	150.00	150.00	150.00	M2b.n
b.nwtx	Stations		Number of stations serviced per trucl			1.00	1.00	1.00	1.00	M2b.n
b.nwtx			Assumed time to take on gasoline at			-	-	-	-	M2b.n
b.nwtx					methanol a	3.00	3.00	3.00	3.00	M2b.n
b.nwtx			Trip cost per truck			450.00	450.00	450.00	450.00	M2b.n
b.nwtx		Trip cost per gallon M85				0.05	0.05	0.05	0.05	M2b.n
b.nwtx	Blending	Fuel cost associated with in-truck blending:								M2b.n
b.nwtx			Gasoline price @ rack (/gal gasoline)			0.89	0.89	0.89	0.89	M2b.n
b.nwtx			Cost of 0.15 gal gasoline			0.13	0.13	0.13	0.13	M2b.n
b.nwtx			Savings of -.15 gal of alcohol			-0.10	-0.10	-0.16	-0.16	M2b.n
b.nwtx		Total cost of M85 fuel delivered to refueling statio				0.76	0.76	1.10	1.10	M2b.n
b.nwtx		Delivered cost with wholesale transaction tax (/g				0.76	0.76	1.11	1.11	M2b.n
b.nwtx	Retailing	Total retail margin with new methanol facility installation:								M2b.n
b.nwtx			Total cost (materials and installation)			0.00	103000.00	0.00	103000.00	M2b.n
b.nwtx			Cost after tax deduction (28.65% tot			0.00	86567.55	0.00	86567.55	M2b.n
b.nwtx			CRF (10% DR, 20 yr life)			0.12	0.12	0.12	0.12	M2b.n
b.nwtx			Annual throughput M85 (1000 gal)			1274.96	1274.96	1274.96	1274.96	M2b.n
b.nwtx			Annualized capital cost (/gal)			0.00	0.01	0.00	0.01	M2b.n
b.nwtx			Transaction Cost Margin			0.03	0.03	0.03	0.03	M2b.n
b.nwtx			Additional Cost Margin (see Appendi			0.03	0.03	0.03	0.03	M2b.n
b.nwtx		Total Retail Margin				0.06	0.07	0.06	0.07	M2b.n
b.nwtx		Total cost of M85 fuel at the pump (/gal M85)				0.82	0.83	1.16	1.17	M2b.n
b.nwtx	Fuel taxes	Federal, state, and local fuel taxes:								M2b.n
b.nwtx			Federal excise tax (/gal)			0.08	0.08	0.08	0.08	M2b.n
b.nwtx			State fuel tax (/gal)			0.08	0.08	0.08	0.08	M2b.n
b.nwtx			City and County of Honolulu fuel tax			0.09	0.09	0.09	0.09	M2b.n
b.nwtx			Federal energy tax (/gal)			0.04	0.04	0.04	0.04	M2b.n
b.nwtx		Total taxes (/gal M85)				0.29	0.29	0.29	0.29	M2b.n
b.nwtx										M2b.n
b.nwtx		Total cost after fuel taxes at station (/gal M85)				1.11	1.12	1.45	1.46	M2b.n
b.nwtx	Sales tax	Plus state excise tax on retail sales				1.15	1.15	1.50	1.51	M2b.n
b.nwtx										M2b.n
b.nwtx	Total cost of M85 fuel at the pump(/gal gasoline equivalent)					2.00	2.01	2.62	2.63	M2b.n
b.nwtx	M2b.nwtx	M2b.nwtx	M2b.nwtx	M2b.nwtx	M2b.nwtx	M2b.nwtx	M2b.nwtx	M2b.nwtx	M2b.nwtx	M2b.n

Scenario M3	
Methanol (10, 67, and 375 million gpy) from Neighbor Island Banagrass, Shipped to Oahu, Sold as M85 (M3)	
Annual demand/supply (10^6 gpy M100) (1)	10
Assumed plant size (mgpy) (1)	10
Annual demand/supply (10^6 gpy M100) (2)	67
Assumed plant size (mgpy) (2)	67
Annual demand/supply (10^6 gpy M100) (3)	375
Assumed plant size (mgpy) (3)	125
Feedstock type	Banagrass
Number of Refueling Stations (1)	59
Number of Refueling Stations (2)	394
Number of Refueling Stations (3)	400
Feedstock price/ton (low)	$52.19
Feedstock price/ton (high)	$84.76
Plant Gate FOB Price (/gal M100) (1)(low)	$0.99
Plant Gate FOB Price (/gal M100) (1)(high)	$1.53
Plant Gate FOB Price (/gal M100) (2)(low)	$0.73
Plant Gate FOB Price (/gal M100) (2)(high)	$1.17
Plant Gate FOB Price (/gal M100) (3)(low)	$0.67
Plant Gate FOB Price (/gal M100) (3)(high)	$1.09
Business income tax rate	35%
Federal tax credit for alcohol from biomass	$0.54
Round trip mileage (low)	100
Round trip mileage (high)	200
Average trip speed (mph)	30
Time to load/unload (hours)	1
Terminal (e.g. Hilo) cost/gal M100 (1)(low)	$0.08
Terminal (e.g. Hilo) cost/gal M100 (1)(high)	$0.10
Terminal (e.g. Hilo) cost/gal M100 (2)(low)	$0.01
Terminal (e.g. Hilo) cost/gal M100 (2)(high)	$0.02
Terminal (e.g. Hilo) cost/gal M100 (3)(low)	$0.01
Terminal (e.g. Hilo) cost/gal M100 (3)(high)	$0.01
Barging cost/gal (low)	$0.04
Barging cost/gal (high)	$0.05
Terminal (e.g. Barbers Pt.) cost/gal M100 (1)(low)	$0.08
Terminal (e.g. Barbers Pt.) cost/gal M100 (1)(high)	$0.12
Terminal (e.g. Barbers Pt.) cost/gal M100 (2)(low)	$0.01
Terminal (e.g. Barbers Pt.) cost/gal M100 (2)(high)	$0.02
Terminal (e.g. Barbers Pt.) cost/gal M100 (3)(low)	$0.01
Terminal (e.g. Barbers Pt.) cost/gal M100 (3)(high)	$0.01

INPUTS FOR ALCOHOL SCENARIOS

(Note: some information is used in more than one scenario.)

M3	M3	M3 M3 M3 M3	M3	M3	M3	M3	M3
M3	COST CATEGORY	ASSUMPTIONS AND FUEL COST ELEMENTS	COST ESTIMATES		COST ESTIMATES		M3
M3			low	high	low	high	M3
M3	Parameters	Annual demand/supply (10^6 gpy M100)	**10**	**10**	**375**	**375**	M3
M3		Assumed plant size (mgpy)	10	10	125	125	M3
M3		Feedstock type	Banagrass	Banagrass	Banagrass	Banagrass	M3
M3		Number of refueling stations	59	59	400	400	M3
M3		Annual throughput per station (1000 gal M85)	200	200	1103	1103	M3
M3		Annual demand/supply (10^6 gpy M85)	12	12	441	441	M3
M3	Plant gate p	Feedstock price (/ton)	$52	$85	$52	$85	M3
M3		Plant Gate FOB Price (/gal M100)	$0.99	$1.53	$0.67	$1.09	M3
M3		Company assumed profitable?	yes	no	yes	no	M3
M3		Federal business income tax rate	35%	35%	35%	35%	M3
M3		Biomass alcohol fuel credit after taxes (/gal M100	$0.00	$0.00	$0.00	$0.00	M3
M3		Plant gate price after tax credit	$0.99	$1.53	$0.67	$1.09	M3
M3		Plus wholesale transaction tax	$0.99	$1.53	$0.67	$1.09	M3
M3	Transport t	Tank truck capacity (gal)	8500	8500	8500	8500	M3
M3	terminal via	Hourly rate (/hr)	$150	$150	$150	$150	M3
M3	truck	Round trip mileage	100	200	100	200	M3
M3		Total hours per round trip including loading and u	4	7	4	7	M3
M3		Total transport cost (/gal M100)	$0.07	$0.12	$0.07	$0.12	M3
M3		Total cost delivered to terminal (/gal M100)	$1.06	$1.66	$0.74	$1.22	M3
M3	Terminallin	Storage at harbor (Hilo); barging to Oahu:					M3
M3	and shipping	Terminal cost (/gal)	$0.08	$0.10	$0.01	$0.01	M3
M3		Barging cost - bulk transport (/gal):	$0.04	$0.05	$0.04	$0.05	M3
M3		Total landed cost (/gal M100)	$1.18	$1.81	$0.79	$1.28	M3
M3	Terminallin	Terminalling + Trucking (Oahu):					M3
M3	Trucking from	Terminal cost (/gal M100)	$0.08	$0.12	$0.01	$0.01	M3
M3	Rack to Station	Trucking cost (/gal M85)	$0.05	$0.05	$0.05	$0.05	M3
M3	Blending	Labor and fuel cost associated with blending:					M3
M3		Gasoline rack price (/gal gasoline)	$0.89	$0.89	$0.89	$0.89	M3
M3		Cost of 0.15 gal gasoline	$0.13	$0.13	$0.13	$0.13	M3
M3		Savings of -.15 gal of alcohol	($0.19)	($0.29)	($0.12)	($0.19)	M3
M3		Total cost of methanol to refueling station (/gal M	$1.26	$1.83	$0.86	$1.28	M3
M3		Delivered cost with wholesale transaction tax (/g	$1.27	$1.84	$0.87	$1.29	M3
M3	Retailing	Retail margin with new methanol facility installation:					M3
M3		Total cost (materials and installation)	$0	$103,000	$0	$103,000	M3
M3		Cost after tax deduction (28.65% tot	$0	$86,568	$0	$86,568	M3
M3		CRF (10% DR, 20 yr life)	0.117	0.117	0.117	0.117	M3
M3		Annual throughput of M85 (1000 gal	200	200	1103	1103	M3
M3		Annualized capital cost (/gal)	$0.00	$0.05	$0.00	$0.01	M3
M3		Transaction Cost Margin	$0.03	$0.03	$0.03	$0.03	M3
M3		Additional Cost Margin (see Appendi	$0.03	$0.03	$0.03	$0.03	M3
M3		Total Retail Margin	$0.06	$0.11	$0.06	$0.07	M3
M3		Total cost of M85 fuel at the pump (/gal M85)	$1.32	$1.94	$0.92	$1.35	M3
M3	Fuel taxes	Federal, state, and local fuel taxes:					M3
M3		Federal excise tax (/gal)	$0.08	$0.08	$0.08	$0.08	M3
M3		State fuel tax (/gal)	$0.16	$0.16	$0.16	$0.16	M3
M3		City and County of Honolulu fuel tax	$0.17	$0.17	$0.17	$0.17	M3
M3		Federal energy tax (/gal)	$0.04	$0.04	$0.04	$0.04	M3
M3		Total taxes (/gal M85)	$0.45	$0.45	$0.45	$0.45	M3
M3		Total cost after fuel taxes at station (/gal M85)	$1.77	$2.39	$1.37	$1.80	M3
M3	Sales tax	Plus state excise tax on retail sales	$1.77	$2.39	$1.37	$1.80	M3
M3	**Total cost of M85 fuel at the pump(/gal gasoline equivale**		**$3.09**	**$4.16**	**$2.39**	**$3.13**	M3
M3	M3	M3 M3 M3 M3	M3	M3	M3	M3	M3

.nwtx	M3 .nwtx	M3 .nwtx	M3 .nwtx	M3 .nwtx	M3 .nwtx	M3 .nwtx	M3 .nwtx	M3 .nwtx	M3 .nwtx	M3 .n
.nwtx	COST	ASSUMPTIONS AND FUEL COST ELEMENTS				COST ESTIMATES		COST ESTIMATES		M3 .n
.nwtx	CATEGORY					low	high	low	high	M3 .n
.nwtx	Parameters	Annual demand/supply (10^6 gpy M100)				10.00	10.00	375.00	375.00	M3 .n
.nwtx		Assumed plant size (mgpy)				10.00	10.00	125.00	125.00	M3 .n
.nwtx		Feedstock type				Banagrass	Banagrass	Banagrass	Banagrass	M3 .n
.nwtx		Number of refueling stations				58.82	58.82	400.00	400.00	M3 .n
.nwtx		Annual throughput per station (1000 gal M85)				200.00	200.00	1102.94	1102.94	M3 .n
.nwtx		Annual demand/supply (10^6 gpy M85)				11.76	11.76	441.18	441.18	M3 .n
.nwtx	Plant gate p	Feedstock price (/ton)				52.19	84.76	52.19	84.76	M3 .n
.nwtx		Plant Gate FOB Price (/gal M100)				0.99	1.53	0.67	1.09	M3 .n
.nwtx		Company assumed profitable?				yes	no	yes	no	M3 .n
.nwtx		Federal business income tax rate				0.35	0.35	0.35	0.35	M3 .n
.nwtx		Biomass alcohol fuel credit after taxes (/gal M100				0.00	0.00	0.00	0.00	M3 .n
.nwtx		Plant gate price after tax credit				0.99	1.53	0.67	1.09	M3 .n
.nwtx		Plus wholesale transaction tax				0.99	1.53	0.67	1.09	M3 .n
.nwtx	Transport tc	Tank truck capacity (gal)				8500.00	8500.00	8500.00	8500.00	M3 .n
.nwtx	terminal via	Hourly rate (/hr)				150.00	150.00	150.00	150.00	M3 .n
.nwtx	truck	Round trip mileage				100.00	200.00	100.00	200.00	M3 .n
.nwtx		Total hours per round trip including loading and u				4.00	7.00	4.00	7.00	M3 .n
.nwtx		Total transport cost (/gal M100)				0.07	0.12	0.07	0.12	M3 .n
.nwtx		Total cost delivered to terminal (/gal M100)				1.06	1.66	0.74	1.22	M3 .n
.nwtx	Terminallinç	Storage at harbor (Hilo); barging to Oahu:								M3 .n
.nwtx	and shipping		Terminal cost (/gal)			0.08	0.10	0.01	0.01	M3 .n
.nwtx			Barging cost - bulk transport (/gal):			0.04	0.05	0.04	0.05	M3 .n
.nwtx		Total landed cost (/gal M100)				1.18	1.81	0.79	1.28	M3 .n
.nwtx	Trucking from		Terminal cost (/gal M100)			0.08	0.12	0.01	0.01	M3 .n
.nwtx	Rack to Station		Trucking cost (/gal M85)			0.05	0.05	0.05	0.05	M3 .n
.nwtx	Blending	Labor and fuel cost associated with blending:								M3 .n
.nwtx			Gasoline rack price (/gal gasoline)			0.89	0.89	0.89	0.89	M3 .n
.nwtx			Cost of 0.15 gal gasoline			0.13	0.13	0.13	0.13	M3 .n
.nwtx			Savings of -.15 gal of alcohol			-0.19	-0.29	-0.12	-0.19	M3 .n
.nwtx		Total cost of methanol to refueling station (/gal M8				1.26	1.83	0.86	1.28	M3 .n
.nwtx		Delivered cost with wholesale transaction tax (/g M				1.27	1.84	0.87	1.29	M3 .n
.nwtx			Total cost (materials and installation)			0.00	103000.00	0.00	103000.00	M3 .n
.nwtx			Cost after tax deduction (28.65% tota			0.00	86567.55	0.00	86567.55	M3 .n
.nwtx			CRF (10% DR, 20 yr life)			0.12	0.12	0.12	0.12	M3 .n
.nwtx			Annual throughput of M85 (1000 gal)			200.00	200.00	1102.94	1102.94	M3 .n
.nwtx			Annualized capital cost (/gal)			0.00	0.05	0.00	0.01	M3 .n
.nwtx			Transaction Cost Margin			0.03	0.03	0.03	0.03	M3 .n
.nwtx			Additional Cost Margin (see Appendi			0.03	0.03	0.03	0.03	M3 .n
.nwtx		Total Retail Margin				0.06	0.11	0.06	0.07	M3 .n
.nwtx		Total cost of M85 fuel at the pump (/gal M85)				1.32	1.94	0.92	1.35	M3 .n
.nwtx			Federal excise tax (/gal)			0.08	0.08	0.08	0.08	M3 .n
.nwtx			State fuel tax (/gal)			0.08	0.08	0.08	0.08	M3 .n
.nwtx			City and County of Honolulu fuel tax			0.09	0.09	0.09	0.09	M3 .n
.nwtx			Federal energy tax (/gal)			0.04	0.04	0.04	0.04	M3 .n
.nwtx		Total taxes (/gal M85)				0.29	0.29	0.29	0.29	M3 .n
.nwtx		Total cost after fuel taxes at station (/gal M85)				1.61	2.23	1.21	1.64	M3 .n
.nwtx	Sales tax	Plus state excise tax on retail sales				1.61	2.23	1.21	1.64	M3 .n
.nwtx	Total cost of M85 fuel at the pump(/gal gasoline equivalent)					2.82	3.89	2.12	2.86	M3 .n
.nwtx	M3 .nwtx	M3 .nwtx	M3 .nwtx	M3 .nwtx	M3 .nwtx	M3 .nwtx	M3 .nwtx	M3 .nwtx	M3 .nwtx	M3 .n

M3	M3	M3	M3
M3	COST ESTIMATES		M3
M3	low	high	M3
M3	67	67	M3
M3	67	67	M3
M3	Banagrass	Banagrass	M3
M3	394	394	M3
M3	200	200	M3
M3	79	79	M3
M3	$52.19	$84.76	M3
M3	$0.73	$1.17	M3
M3	yes	no	M3
M3	35%	35%	M3
M3	$0.25	$0.00	M3
M3	$0.48	$1.17	M3
M3	$0.49	$1.18	M3
M3	8500	8500	M3
M3	$150	$150	M3
M3	100	200	M3
M3	4	7	M3
M3	$0.07	$0.12	M3
M3	$0.56	$1.30	M3
M3			M3
M3	$0.01	$0.02	M3
M3	$0.04	$0.05	M3
M3	$0.61	$1.37	M3
M3			M3
M3	$0.01	$0.02	M3
M3	$0.05	$0.05	M3
M3			M3
M3	$0.89	$0.89	M3
M3	$0.13	$0.13	M3
M3	($0.09)	($0.21)	M3
M3	$0.71	$1.36	M3
M3	$0.72	$1.37	M3
M3			M3
M3	$0	$103,000	M3
M3	$0	$86,568	M3
M3	0.117	0.117	M3
M3	200	200	M3
M3	$0.00	$0.05	M3
M3	$0.03	$0.03	M3
M3	$0.03	$0.03	M3
M3	$0.06	$0.11	M3
M3	$0.77	$1.47	M3
M3			M3
M3	$0.08	$0.08	M3
M3	$0.16	$0.16	M3
M3	$0.17	$0.17	M3
M3	$0.04	$0.04	M3
M3	$0.45	$0.45	M3
M3	$1.22	$1.92	M3
M3	$1.22	$1.92	M3
M3	**$2.13**	**$3.35**	M3
M3	M3	M3	M3

.nwtx	M3 .nwtx	M3 .nwtx	M3 .nwtx	M3 .nwtx	M3 .nwtx	M3 .nwtx	M3 .nwtx	M3 .nwtx	M3 .nwtx	M3 .n
.nwtx	COST	ASSUMPTIONS AND FUEL COST ELEMENTS				COST ESTIMATES		COST ESTIMATES		M3 .n
.nwtx	CATEGORY					low	high	low	high	M3 .n
.nwtx	Parameters	Annual demand/supply (10^6 gpy M100)				10.00	10.00	375.00	375.00	M3 .n
.nwtx		Assumed plant size (mgpy)				10.00	10.00	125.00	125.00	M3 .n
.nwtx		Feedstock type				Banagrass	Banagrass	Banagrass	Banagrass	M3 .n
.nwtx		Number of refueling stations				58.82	58.82	400.00	400.00	M3 .n
.nwtx		Annual throughput per station (1000 gal M85)				200.00	200.00	1102.94	1102.94	M3 .n
.nwtx		Annual demand/supply (10^6 gpy M85)				11.76	11.76	441.18	441.18	M3 .n
.nwtx	Plant gate p	Feedstock price (/ton)				52.19	84.76	52.19	84.76	M3 .n
.nwtx		Plant Gate FOB Price (/gal M100)				0.99	1.53	0.67	1.09	M3 .n
.nwtx		Company assumed profitable?				yes	no	yes	no	M3 .n
.nwtx		Federal business income tax rate				0.35	0.35	0.35	0.35	M3 .n
.nwtx		Biomass alcohol fuel credit after taxes (/gal M100				0.00	0.00	0.00	0.00	M3 .n
.nwtx		Plant gate price after tax credit				0.99	1.53	0.67	1.09	M3 .n
.nwtx		Plus wholesale transaction tax				0.99	1.53	0.67	1.09	M3 .n
.nwtx	Transport tc	Tank truck capacity (gal)				8500.00	8500.00	8500.00	8500.00	M3 .n
.nwtx	terminal via	Hourly rate (/hr)				150.00	150.00	150.00	150.00	M3 .n
.nwtx	truck	Round trip mileage				100.00	200.00	100.00	200.00	M3 .n
.nwtx		Total hours per round trip including loading and u				4.00	7.00	4.00	7.00	M3 .n
.nwtx		Total transport cost (/gal M100)				0.07	0.12	0.07	0.12	M3 .n
.nwtx		Total cost delivered to terminal (/gal M100)				1.06	1.66	0.74	1.22	M3 .n
.nwtx	Terminalling	Storage at harbor (Hilo); barging to Oahu:								M3 .n
.nwtx	and shipping		Terminal cost (/gal)			0.08	0.10	0.01	0.01	M3 .n
.nwtx			Barging cost - bulk transport (/gal):			0.04	0.05	0.04	0.05	M3 .n
.nwtx		Total landed cost (/gal M100)				1.18	1.81	0.79	1.28	M3 .n
.nwtx	Trucking from		Terminal cost (/gal M100)			0.08	0.12	0.01	0.01	M3 .n
.nwtx	Rack to Station		Trucking cost (/gal M85)			0.05	0.05	0.05	0.05	M3 .n
.nwtx	Blending	Labor and fuel cost associated with blending:								M3 .n
.nwtx			Gasoline rack price (/gal gasoline)			0.89	0.89	0.89	0.89	M3 .n
.nwtx			Cost of 0.15 gal gasoline			0.13	0.13	0.13	0.13	M3 .n
.nwtx			Savings of -.15 gal of alcohol			-0.19	-0.29	-0.12	-0.19	M3 .n
.nwtx		Total cost of methanol to refueling station (/gal M				1.26	1.83	0.86	1.28	M3 .n
.nwtx		Delivered cost with wholesale transaction tax (/g				1.27	1.84	0.87	1.29	M3 .n
.nwtx			Total cost (materials and installation)			0.00	103000.00	0.00	103000.00	M3 .n
.nwtx			Cost after tax deduction (28.65% tota			0.00	86567.55	0.00	86567.55	M3 .n
.nwtx			CRF (10% DR, 20 yr life)			0.12	0.12	0.12	0.12	M3 .n
.nwtx			Annual throughput of M85 (1000 gal)			200.00	200.00	1102.94	1102.94	M3 .n
.nwtx			Annualized capital cost (/gal)			0.00	0.05	0.00	0.01	M3 .n
.nwtx			Transaction Cost Margin			0.03	0.03	0.03	0.03	M3 .n
.nwtx			Additional Cost Margin (see Appendi			0.03	0.03	0.03	0.03	M3 .n
.nwtx		Total Retail Margin				0.06	0.11	0.06	0.07	M3 .n
.nwtx		Total cost of M85 fuel at the pump (/gal M85)				1.32	1.94	0.92	1.35	M3 .n
.nwtx			Federal excise tax (/gal)			0.08	0.08	0.08	0.08	M3 .n
.nwtx			State fuel tax (/gal)			0.08	0.08	0.08	0.08	M3 .n
.nwtx			City and County of Honolulu fuel tax			0.09	0.09	0.09	0.09	M3 .n
.nwtx			Federal energy tax (/gal)			0.04	0.04	0.04	0.04	M3 .n
.nwtx		Total taxes (/gal M85)				0.29	0.29	0.29	0.29	M3 .n
.nwtx		Total cost after fuel taxes at station (/gal M85)				1.61	2.23	1.21	1.64	M3 .n
.nwtx	Sales tax	Plus state excise tax on retail sales				1.61	2.23	1.21	1.64	M3 .n
.nwtx	Total cost of M85 fuel at the pump(/gal gasoline equivalent)					2.82	3.89	2.12	2.86	M3 .n
.nwtx	M3 .nwtx	M3 .nwtx	M3 .nwtx	M3 .nwtx	M3 .nwtx	M3 .nwtx	M3 .nwtx	M3 .nwtx	M3 .nwtx	M3 .n

M3 .nwtx	M3 .nwtx	M3 .nwtx	M3 .nwtx
M3 .nwtx	COST ESTIMATES		M3 .nwtx
M3 .nwtx	low	high	M3 .nwtx
M3 .nwtx	67.00	67.00	M3 .nwtx
M3 .nwtx	67.00	67.00	M3 .nwtx
M3 .nwtx	Banagrass	Banagrass	M3 .nwtx
M3 .nwtx	394.12	394.12	M3 .nwtx
M3 .nwtx	200.00	200.00	M3 .nwtx
M3 .nwtx	78.82	78.82	M3 .nwtx
M3 .nwtx	52.19	84.76	M3 .nwtx
M3 .nwtx	0.73	1.17	M3 .nwtx
M3 .nwtx	yes	no	M3 .nwtx
M3 .nwtx	0.35	0.35	M3 .nwtx
M3 .nwtx	0.25	0.00	M3 .nwtx
M3 .nwtx	0.48	1.17	M3 .nwtx
M3 .nwtx	0.49	1.18	M3 .nwtx
M3 .nwtx	8500.00	8500.00	M3 .nwtx
M3 .nwtx	150.00	150.00	M3 .nwtx
M3 .nwtx	100.00	200.00	M3 .nwtx
M3 .nwtx	4.00	7.00	M3 .nwtx
M3 .nwtx	0.07	0.12	M3 .nwtx
M3 .nwtx	0.56	1.30	M3 .nwtx
M3 .nwtx			M3 .nwtx
M3 .nwtx	0.01	0.02	M3 .nwtx
M3 .nwtx	0.04	0.05	M3 .nwtx
M3 .nwtx	0.61	1.37	M3 .nwtx
M3 .nwtx			M3 .nwtx
M3 .nwtx	0.01	0.02	M3 .nwtx
M3 .nwtx	0.05	0.05	M3 .nwtx
M3 .nwtx			M3 .nwtx
M3 .nwtx	0.89	0.89	M3 .nwtx
M3 .nwtx	0.13	0.13	M3 .nwtx
M3 .nwtx	-0.09	-0.21	M3 .nwtx
M3 .nwtx	0.71	1.36	M3 .nwtx
M3 .nwtx	0.72	1.37	M3 .nwtx
M3 .nwtx			M3 .nwtx
M3 .nwtx	0.00	103000.00	M3 .nwtx
M3 .nwtx	0.00	86567.55	M3 .nwtx
M3 .nwtx	0.12	0.12	M3 .nwtx
M3 .nwtx	200.00	200.00	M3 .nwtx
M3 .nwtx	0.00	0.05	M3 .nwtx
M3 .nwtx	0.03	0.03	M3 .nwtx
M3 .nwtx	0.03	0.03	M3 .nwtx
M3 .nwtx	0.06	0.11	M3 .nwtx
M3 .nwtx	0.77	1.47	M3 .nwtx
M3 .nwtx			M3 .nwtx
M3 .nwtx	0.08	0.08	M3 .nwtx
M3 .nwtx	0.08	0.08	M3 .nwtx
M3 .nwtx	0.09	0.09	M3 .nwtx
M3 .nwtx	0.04	0.04	M3 .nwtx
M3 .nwtx	0.29	0.29	M3 .nwtx
M3 .nwtx			M3 .nwtx
M3 .nwtx	1.07	1.77	M3 .nwtx
M3 .nwtx	1.07	1.77	M3 .nwtx
M3 .nwtx			M3 .nwtx
M3 .nwtx	1.86	3.08	M3 .nwtx
M3 .nwtx	M3 .nwtx	M3 .nwtx	M3 .nwtx

Scenario E1a	
Ethanol (6000 and 170000 gpy, containerized) Shipped from Mainland, Sold as E85 (E1a)	
Annual demand/supply (1000 gal E85) (1)	7
Annual demand/supply (1000 gal E85) (2)	200
Number of refueling locations	1
Washington State 1993 spot price	$1.46
Shipping cost per container (low)	$4,000
Shipping cost per container (high)	$6,000
Hauling (loaded rate/hr)	$75
Tankwagon margin/gal	$0.03

INPUTS FOR ALCOHOL SCENARIOS

(Note: some information is used in more than one scenario.)

E1a	E1a	E1a E1a E1a E1a	E1a	E1a	E1a	E1a	E1a
E1a	COST	ASSUMPTIONS AND FUEL COST ELEMENTS	COST ESTIMATES		COST ESTIMATES		E1a
E1a	CATEGORY		low	high	low	high	E1a
E1a	Parameters	Annual demand/supply (1000 gal E85)	**7**	**7**	**200**	**200**	E1a
E1a		Annual demand/supply E100 (1000 gal)	6	6	170	170	E1a
E1a		Shipping container (tank) size (gal)	6100	6100	6100	6100	E1a
E1a		Number of tanks shipped per year	1.0	1.0	28.0	28.0	E1a
E1a		Actual volume imported via containers (1000 gal	6.1	6.1	170.8	170.8	E1a
E1a		Number of refueling locations	1	1	1	1	E1a
E1a		Annual throughput per station (1000 gal E85)	7.18	7.18	201	201	E1a
E1a	Mainland pr	Price loaded onto ship (/gal)					E1a
E1a		Washington State 1993 spot price	$1.46	$1.46	$1.46	$1.46	E1a
E1a	Shipping	Shipping cost (/gal E100):					E1a
E1a	Shipping cost per conti	$4000 to $6000 per container	$0.66	$0.98	$0.66	$0.98	E1a
E1a		Total landed cost (/gal E100)	$2.12	$2.44	$2.12	$2.44	E1a
E1a	Truck	Hauling from harbor to stations and transfer to station tank:					E1a
E1a	Transport of	Hauling (loaded rate/hr)	$75	$75	$75	$75	E1a
E1a	Containers to	Number of truck trips per station/ yea	1	1	33	33	E1a
E1a	Stations	Trip cost per truck	$200	$200	$200	$200	E1a
E1a		Trip cost per gallon (/gal E100)	$0.03	$0.03	$0.03	$0.03	E1a
E1a		Total cost of ethanol to refueling station (/gal E10	$2.14	$2.47	$2.15	$2.48	E1a
E1a		Delivered cost with wholesale transaction tax (/ga	$2.15	$2.48	$2.16	$2.49	E1a
E1a	Blending	Labor and fuel cost associated with blending:					E1a
E1a		Gasoline price @ rack (/gal gasoline)	$0.89	$0.89	$0.89	$0.89	E1a
E1a		Gasoline tankwagon price (/gal gasol	$0.92	$0.92	$0.92	$0.92	E1a
E1a		Cost of 0.15 gal gasoline	$0.14	$0.14	$0.14	$0.14	E1a
E1a		Savings of -.15 gal of alcohol	($0.32)	($0.37)	($0.32)	($0.37)	E1a
E1a		Labor cost (/year)	$75.00	$75.00	$2,475.00	$2,475.00	E1a
E1a		Total cost of E85 fuel (/gal)	$1.98	$2.26	$1.98	$2.27	E1a
E1a	Retailing	Total retail margin with new ethanol facility installation:					E1a
E1a		Total cost (materials and installation)	$0	$103,000	$0	$103,000	E1a
E1a		Cost after tax deduction (28.65% tota	$0	$86,568	$0	$86,568	E1a
E1a		CRF (10% DR, 20 yr life)	0.117	0.117	0.117	0.117	E1a
E1a		Annual throughput E85 (1000 gal)	7	7	201	201	E1a
E1a		Annualized capital cost (/gal E85)	$0.00	$1.42	$0.00	$0.05	E1a
E1a		Transaction Cost Margin	$0.03	$0.03	$0.03	$0.03	E1a
E1a		Additional Cost Margin	$0.03	$0.03	$0.03	$0.03	E1a
E1a		Total Retail Margin	$0.06	$1.48	$0.06	$0.11	E1a
E1a		Total cost of E85 fuel at the pump (/gal)	$2.04	$3.74	$2.04	$2.38	E1a
E1a	Fuel taxes	Federal, state, and local fuel taxes:					E1a
E1a		Federal excise tax (/gal)	$0.09	$0.09	$0.09	$0.09	E1a
E1a		State fuel tax (/gal)	$0.16	$0.16	$0.16	$0.16	E1a
E1a		City and County of Honolulu fuel tax	$0.17	$0.17	$0.17	$0.17	E1a
E1a		Federal energy tax (/gal)	$0.04	$0.04	$0.04	$0.04	E1a
E1a		Total taxes (/gal E85)	$0.45	$0.45	$0.45	$0.45	E1a
E1a		Total cost after fuel taxes at station (/gal E85)	$2.49	$4.19	$2.50	$2.83	E1a
E1a	Sales tax	Plus state excise tax on retail sales	$2.49	$4.19	$2.50	$2.83	E1a
E1a							E1a
E1a	**Total cost of E85 fuel at the pump(/gal gasoline equivale**		**$3.48**	**$5.85**	**$3.49**	**$3.95**	E1a
E1a	Notes:	a) Station throughput per year assumed to be greater than one 6100 gallon tank of E100. Number of stations kept at one until an annual throughput of about 200,000 gallons E85 has been acheived.					E1a E1a E1a
E1a	E1a	E1a E1a E1a E1a	E1a	E1a	E1a	E1a	E1a

.nwtx	E1a.nwtx	E1a.nwtx	E1a.nwtx	E1a.nwtx	E1a.nwtx	E1a.nwtx	E1a.nwtx	E1a.nwtx	E1a.nwtx	E1a.n
.nwtx	COST	ASSUMPTIONS AND FUEL COST ELEMENTS				COST ESTIMATES		COST ESTIMATES		E1a.n
.nwtx	CATEGORY					low	high	low	high	E1a.n
.nwtx	Parameters	Annual demand/supply (1000 gal E85)				7.00	7.00	200.00	200.00	E1a.n
.nwtx		Annual demand/supply E100 (1000 gal)				6.00	6.00	170.00	170.00	E1a.n
.nwtx		Shipping container (tank) size (gal)				6100.00	6100.00	6100.00	6100.00	E1a.n
.nwtx		Number of tanks shipped per year				1.00	1.00	28.00	28.00	E1a.n
.nwtx		Actual volume imported via containers (1000 gal E				6.10	6.10	170.80	170.80	E1a.n
.nwtx		Number of refueling locations				1.00	1.00	1.00	1.00	E1a.n
.nwtx		Annual throughput per station (1000 gal E85)				7.18	7.18	200.94	200.94	E1a.n
.nwtx	Mainland pr	Price loaded onto ship (/gal)				0.00	0.00	0.00	0.00	E1a.n
.nwtx			Washington State 1993 spot price			1.46	1.46	1.46	1.46	E1a.n
.nwtx	Shipping	Shipping cost (/gal E100):				0.00	0.00	0.00	0.00	E1a.n
.nwtx		Shipping co	Shipping cost from $4000 to $6000 p			0.66	0.98	0.66	0.98	E1a.n
.nwtx		Total landed cost (/gal E100)				2.12	2.44	2.12	2.44	E1a.n
.nwtx	Truck	Hauling from harbor to stations and transfer to station tank:								E1a.n
.nwtx	Transport of		Hauling (loaded rate/hr)			75.00	75.00	75.00	75.00	E1a.n
.nwtx	Containers to		Number of truck trips per station/ yea			1.00	1.00	33.00	33.00	E1a.n
.nwtx	Stations		Trip cost per truck			200.00	200.00	200.00	200.00	E1a.n
.nwtx		Trip cost per gallon (/gal E100)				0.03	0.03	0.03	0.03	E1a.n
.nwtx		Total cost of ethanol to refueling station (/gal E10				2.14	2.47	2.15	2.48	E1a.n
.nwtx		Delivered cost with wholesale transaction tax (/ga				2.15	2.48	2.16	2.49	E1a.n
.nwtx	Blending	Labor and fuel cost associated with blending:								E1a.n
.nwtx			Gasoline price @ rack (/gal gasoline			0.89	0.89	0.89	0.89	E1a.n
.nwtx			Gasoline tankwagon price (/gal gasol			0.92	0.92	0.92	0.92	E1a.n
.nwtx			Cost of 0.15 gal gasoline			0.14	0.14	0.14	0.14	E1a.n
.nwtx			Savings of -.15 gal of alcohol			-0.32	-0.37	-0.32	-0.37	E1a.n
.nwtx			Labor cost (/year)			75.00	75.00	2475.00	2475.00	E1a.n
.nwtx	0.00	Total cost o	0.00			1.98	2.26	1.98	2.27	E1a.n
.nwtx	Retailing	Total retail margin with new ethanol facility installation:								E1a.n
.nwtx			Total cost (materials and installation)			0.00	103000.00	0.00	103000.00	E1a.n
.nwtx			Cost after tax deduction (28.65% tota			0.00	86567.55	0.00	86567.55	E1a.n
.nwtx			CRF (10% DR, 20 yr life)			0.12	0.12	0.12	0.12	E1a.n
.nwtx			Annual throughput E85 (1000 gal)			7.18	7.18	200.94	200.94	E1a.n
.nwtx			Annualized capital cost (/gal E85)			0.00	1.42	0.00	0.05	E1a.n
.nwtx			Transaction Cost Margin			0.03	0.03	0.03	0.03	E1a.n
.nwtx			Additional Cost Margin			0.03	0.03	0.03	0.03	E1a.n
.nwtx		Total Retail Margin				0.06	1.48	0.06	0.11	E1a.n
.nwtx		Total cost of E85 fuel at the pump (/gal)				2.04	3.74	2.04	2.38	E1a.n
.nwtx	Fuel taxes	Federal, state, and local fuel taxes:								E1a.n
.nwtx			Federal excise tax (/gal)			0.09	0.09	0.09	0.09	E1a.n
.nwtx			State fuel tax (/gal)			0.10	0.10	0.10	0.10	E1a.n
.nwtx			City and County of Honolulu fuel tax			0.11	0.11	0.11	0.11	E1a.n
.nwtx			Federal energy tax (/gal)			0.04	0.04	0.04	0.04	E1a.n
.nwtx		Total taxes (/gal E85)				0.34	0.34	0.34	0.34	E1a.n
.nwtx										E1a.n
.nwtx		Total cost after fuel taxes at station (/gal E85)				2.38	4.08	2.38	2.72	E1a.n
.nwtx	Sales tax	Plus state excise tax on retail sales				2.38	4.08	2.38	2.72	E1a.n
.nwtx										E1a.n
.nwtx	Total cost of E85 fuel at the pump(/gal gasoline equivalent)					3.32	5.69	3.33	3.79	E1a.n
.nwtx	E1a.nwtx	E1a.nwtx	E1a.nwtx	E1a.nwtx	E1a.nwtx	E1a.nwtx	E1a.nwtx	E1a.nwtx	E1a.nwtx	E1a.n

Scenario E2a	
Ethanol (7 and 30 million gpy) from Waste on Oahu, Sold as E85 (E2a)	
Annual demand/supply (10^6 gpy E100) (1)	7
Assumed plant size (mgpy) (1)	7
Annual demand/supply (10^6 gpy E100) (2)	30
Assumed plant size (mgpy) (2)	30
Feedstock	Waste
Number of refueling stations (1)	41
Number of refueling stations (2)	176
Feedstock price/ton (low)	$10
Feedstock price/ton (high)	$30
Grant (% of capital cost)	0%
Capital cost of boiler & utilities included? (Yes or No)	No
Financing: interest rate assumed	8%
Plant Gate FOB Price (/gal E100) (1)(low)	$0.99
Plant Gate FOB Price (/gal E100) (1)(high)	$2.07
Plant Gate FOB Price (/gal E100) (2)(low)	$0.82
Plant Gate FOB Price (/gal E100) (2)(high)	$1.88
Small ethanol producer credit ($/gal)	$0.10
For producers w/capacity less than (mgpy)	30
Credit on up to ____ mgpy ethanol	15
Number of stations serviced per truck	1
Assumed time to take on gasoline at terminal,	3

INPUTS FOR ALCOHOL SCENARIOS M1a

(Note: some information is used in more than one scenario.) M1a

E2a E2a E2a E2a E2a E2a E2a E2a E2a E2a E2a

E2a	COST	ASSUMPTIONS AND FUEL COST ELEMENTS	COST ESTIMATES		COST ESTIMATES		E2a
E2a	CATEGORY		low	high	low	high	E2a
E2a	Parameters	Annual demand/supply (10^6 gpy E100)	7	7	30	30	E2a
E2a		Feedstock	Waste	Waste	Waste	Waste	E2a
E2a		Assumed plant size (mgpy)	7	7	30	30	E2a
E2a		Number of refueling stations	41	41	176	176	E2a
E2a		Annual throughput per station (1000 gal E85)	200	200	200	200	E2a
E2a		Annual demand/supply (10^6 gpy E85)	8	8	35	35	E2a
E2a	Plant gate p	Feedstock price (/ton)	$10	$30	$10	$30	E2a
E2a		Plant Gate FOB Price (/gal E100)	$0.99	$2.07	$0.82	$1.88	E2a
E2a		Company assumed profitable?	yes	no	yes	no	E2a
E2a		Federal business income tax rate	35%	35%	35%	35%	E2a
E2a		Biomass alcohol fuel credit after taxes (/gal E100	$0.00	$0.00	$0.00	$0.00	E2a
E2a		Plant gate price after tax credit (/gal E100)	$0.99	$2.07	$0.82	$1.88	E2a
E2a		Small producer credit (/gal E100)	($0.10)	$0.00	($0.05)	$0.00	E2a
E2a		FOB price including small producer's credit (/gal	$0.89	$2.07	$0.77	$1.88	E2a
E2a		Plus wholesale transaction tax	$0.89	$2.08	$0.78	$1.89	E2a
E2a	Truck	Tank truck to terminal, then to plant					E2a
E2a	Transport to	Loaded labor rate (/hr)	$150	$150	$150	$150	E2a
E2a	Stations	Number of stations serviced per truc	1	1	1	1	E2a
E2a		Assumed time to take on gasoline at	-	-	-	-	E2a
E2a		ethanol at plant and unload at station (hrs)	3	3	3	3	E2a
E2a		Trip cost per truck ()	$450	$450	$450	$450	E2a
E2a		Trip cost per gallon E85 ()	$0.05	$0.05	$0.05	$0.05	E2a
E2a	Blending	Fuel cost associated with in-truck blending:					E2a
E2a		Gasoline price @ rack (/gal gasoline)	$0.89	$0.89	$0.89	$0.89	E2a
E2a		Cost of 0.15 gal gasoline	$0.13	$0.13	$0.13	$0.13	E2a
E2a		Savings of -.15 gal of alcohol	($0.13)	($0.31)	($0.12)	($0.28)	E2a
E2a		Total cost of E85 fuel delivered to refueling statio	$0.94	$1.95	$0.85	$1.79	E2a
E2a		Delivered cost with wholesale transaction tax (/g E	$0.95	$1.96	$0.85	$1.80	E2a
E2a	Retailing	Total retail margin with new ethanol facility installation:					E2a
E2a		Total cost (materials and installation)	$0	$103,000	$0	$103,000	E2a
E2a		Cost after tax deduction (28.65% tota	$0	$86,568	$0	$86,568	E2a
E2a		CRF (10% DR, 20 yr life)	0.117	0.117	0.117	0.117	E2a
E2a		Assumed annual throughput (1000 g	200	200	200	200	E2a
E2a		Annualized capital cost (/gal E85)	$0.00	$0.05	$0.00	$0.05	E2a
E2a		Transaction Cost Margin	$0.03	$0.03	$0.03	$0.03	E2a
E2a		Additional Cost Margin (see Appendi	$0.03	$0.03	$0.03	$0.03	E2a
E2a		Total Retail Margin	$0.06	$0.11	$0.06	$0.11	E2a
E2a		Total cost of E85 fuel at the pump (/gal E85)	$1.01	$2.07	$0.91	$1.91	E2a
E2a	Fuel taxes	Federal, state, and local fuel taxes:					E2a
E2a		Federal excise tax (/gal)	$0.09	$0.09	$0.09	$0.09	E2a
E2a		State fuel tax (/gal)	$0.16	$0.16	$0.16	$0.16	E2a
E2a		City and County of Honolulu fuel tax (	$0.17	$0.17	$0.17	$0.17	E2a
E2a		Federal energy tax (/gal)	$0.04	$0.04	$0.04	$0.04	E2a
E2a		Total taxes (/gal E85)	$0.45	$0.45	$0.45	$0.45	E2a
E2a		Total cost after fuel taxes at station (/gal E85)	$1.46	$2.53	$1.36	$2.37	E2a
E2a	Sales tax	Plus state excise tax on retail sales	$1.46	$2.53	$1.36	$2.37	E2a
E2a							E2a
E2a	**Total cost of E85 fuel at the pump(/gal gasoline equivale**		**$2.04**	**$3.53**	**$1.90**	**$3.30**	E2a
E2a							E2a

E2a E2a E2a E2a E2a E2a E2a E2a E2a E2a E2a

a.nwtx	E2a.nwtx	E2a.nwtx	E2a.nwtx	E2a.nwtx	E2a.nwtx	E2a.nwtx	E2a.nwtx	E2a.nwtx	E2a.nwtx	E2a.n
a.nwtx	COST	ASSUMPTIONS AND FUEL COST ELEMENTS COST ESTIMATES						COST ESTIMATES		E2a.n
a.nwtx	CATEGORY					low	high	low	high	E2a.n
a.nwtx	Parameters	Annual demand/supply (10^6 gpy E100)				7.00	7.00	30.00	30.00	E2a.n
a.nwtx		Feedstock				Waste	Waste	Waste	Waste	E2a.n
a.nwtx		Assumed plant size (mgpy)				7.00	7.00	30.00	30.00	E2a.n
a.nwtx		Number of refueling stations				41.18	41.18	176.47	176.47	E2a.n
a.nwtx		Annual throughput per station (1000 gal E85)				200.00	200.00	200.00	200.00	E2a.n
a.nwtx		Annual demand/supply (10^6 gpy E85)				8.24	8.24	35.29	35.29	E2a.n
a.nwtx	Plant gate p	Feedstock price (/ton)				10.00	30.00	10.00	30.00	E2a.n
a.nwtx		Plant Gate FOB Price (/gal E100)				0.99	2.07	0.82	1.88	E2a.n
a.nwtx		Company assumed profitable?				yes	no	yes	no	E2a.n
a.nwtx		Federal business income tax rate				0.35	0.35	0.35	0.35	E2a.n
a.nwtx		Biomass alcohol fuel credit after taxes (/gal E100)				0.00	0.00	0.00	0.00	E2a.n
a.nwtx		Plant gate price after tax credit (/gal E100)				0.99	2.07	0.82	1.88	E2a.n
a.nwtx		Small producer credit (/gal E100)				-0.10	0.00	-0.05	0.00	E2a.n
a.nwtx		FOB price including small producer's credit (/gal I				0.89	2.07	0.77	1.88	E2a.n
a.nwtx		Plus wholesale transaction tax				0.89	2.08	0.78	1.89	E2a.n
a.nwtx	Truck	Tank truck to terminal, then to plant								E2a.n
a.nwtx	Transport to		Loaded labor rate (/hr)			150.00	150.00	150.00	150.00	E2a.n
a.nwtx	Stations		Number of stations serviced per trucl			1.00	1.00	1.00	1.00	E2a.n
a.nwtx			Assumed time to take on gasoline at			-	-	-	-	E2a.n
a.nwtx			0.00		ethanol at p	3.00	3.00	3.00	3.00	E2a.n
a.nwtx			Trip cost per truck ()			450.00	450.00	450.00	450.00	E2a.n
a.nwtx		Trip cost per gallon E85 ()				0.05	0.05	0.05	0.05	E2a.n
a.nwtx	Blending	Fuel cost associated with in-truck blending:								E2a.n
a.nwtx			Gasoline price @ rack (/gal gasoline)			0.89	0.89	0.89	0.89	E2a.n
a.nwtx			Cost of 0.15 gal gasoline			0.13	0.13	0.13	0.13	E2a.n
a.nwtx			Savings of -.15 gal of alcohol			-0.13	-0.31	-0.12	-0.28	E2a.n
a.nwtx		Total cost of E85 fuel delivered to refueling statioı				0.94	1.95	0.85	1.79	E2a.n
a.nwtx		Delivered cost with wholesale transaction tax (/g E				0.95	1.96	0.85	1.80	E2a.n
a.nwtx	Retailing	Total retail margin with new ethanol facility installation:								E2a.n
a.nwtx			Total cost (materials and installation)			0.00	103000.00	0.00	103000.00	E2a.n
a.nwtx			Cost after tax deduction (28.65% tota			0.00	86567.55	0.00	86567.55	E2a.n
a.nwtx			CRF (10% DR, 20 yr life)			0.12	0.12	0.12	0.12	E2a.n
a.nwtx			Assumed annual throughput (1000 g			200.00	200.00	200.00	200.00	E2a.n
a.nwtx			Annualized capital cost (/gal E85)			0.00	0.05	0.00	0.05	E2a.n
a.nwtx			Transaction Cost Margin			0.03	0.03	0.03	0.03	E2a.n
a.nwtx			Additional Cost Margin (see Appendi			0.03	0.03	0.03	0.03	E2a.n
a.nwtx		Total Retail Margin				0.06	0.11	0.06	0.11	E2a.n
a.nwtx		Total cost of E85 fuel at the pump (/gal E85)				1.01	2.07	0.91	1.91	E2a.n
a.nwtx	Fuel taxes	Federal, state, and local fuel taxes:								E2a.n
a.nwtx			Federal excise tax (/gal)			0.09	0.09	0.09	0.09	E2a.n
a.nwtx			State fuel tax (/gal)			0.10	0.10	0.10	0.10	E2a.n
a.nwtx			City and County of Honolulu fuel tax ı			0.11	0.11	0.11	0.11	E2a.n
a.nwtx			Federal energy tax (/gal)			0.04	0.04	0.04	0.04	E2a.n
a.nwtx		Total taxes (/gal E85)				0.34	0.34	0.34	0.34	E2a.n
a.nwtx										E2a.n
a.nwtx		Total cost after fuel taxes at station (/gal E85)				1.35	2.41	1.25	2.25	E2a.n
a.nwtx	Sales tax	Plus state excise tax on retail sales				1.35	2.41	1.25	2.25	E2a.n
a.nwtx										E2a.n
a.nwtx	Total cost of E85 fuel at the pump(/gal gasoline equivalent)					1.88	3.37	1.74	3.14	E2a.n
a.nwtx	E2a.nwtx	E2a.nwtx	E2a.nwtx	E2a.nwtx	E2a.nwtx	E2a.nwtx	E2a.nwtx	E2a.nwtx	E2a.nwtx	E2a.n

Scenario E2b	
Ethanol (7 and 30 million gpy) from Waste on Oahu, Sold as E10 (E2b)	
Annual demand/supply (10^6 gpy E100) (1)	7
Assumed plant size (mgpy) (1)	7
Annual demand/supply (10^6 gpy E100) (2)	30
Assumed plant size (mgpy) (2)	30
Feedstock	Waste
Target throughput per station (1000 gal)	953
Number of refueling stations (1)	73
Number of refueling stations (2)	315
Feedstock price/ton (low)	$10
Feedstock price/ton (high)	$30
Plant Gate FOB Price (/gal E100) (1)(low)	$0.99
Plant Gate FOB Price (/gal E100) (1)(high)	$2.07
Plant Gate FOB Price (/gal E100) (2)(low)	$0.82
Plant Gate FOB Price (/gal E100) (2)(high)	$1.88
Number of stations serviced per truck	1
Assumed time to take on gasoline at terminal,	3
Added cost/gal for gasoline volatility adjustment	$0.02
Total cost (materials and installation) (low)	$0
Total cost (materials and installation) (high)	$1,000

INPUTS FOR ALCOHOL SCENARIOS

(Note: some information is used in more than one scenario.)

E2b	E2b	E2b	E2b	E2b	E2b	E2b	E2b	E2b	E2b	E2b
E2b	COST	ASSUMPTIONS AND FUEL COST ELEMENTS				COST ESTIMATES		COST ESTIMATES		E2b
E2b	CATEGORY					low	high	low	high	E2b
E2b	Parameters	Annual demand/supply (10^6 gpy E100)				7	7	30	30	E2b
E2b		Feedstock				Waste	Waste	Waste	Waste	E2b
E2b		Assumed plant size (mgpy)				7	7	30	30	E2b
E2b		Number of refueling stations				73	73	315	315	E2b
E2b		Annual throughput per station (1000 gal E10)				953	953	953	953	E2b
E2b	Plant gate p	Feedstock price (/ton)				$10	$30	$10	$30	E2b
E2b		Plant Gate FOB Price (/gal E100)				$0.99	$2.07	$0.82	$1.88	E2b
E2b		Company assumed profitable?				yes	no	yes	no	E2b
E2b		Federal business income tax rate				35%	35%	35%	35%	E2b
E2b		Small producer credit (/gal E100)				($0.10)	$0.00	($0.05)	$0.00	E2b
E2b		FOB price including small producer's credit (/gal				$0.89	$2.07	$0.77	$1.88	E2b
E2b		Plus wholesale transaction tax				$0.89	$2.08	$0.78	$1.89	E2b
E2b	Truck	Tank truck to terminal, then to plant								E2b
E2b	Transport to	Loaded labor rate (/hr)				$150	$150	$150	$150	E2b
E2b	Stations	Number of stations serviced per truc				1	1	1	1	E2b
E2b		Assumed time to take on gasoline at				-	-	-	-	E2b
E2b		ethanol at plant and unload at station (hrs)				3	3	3	3	E2b
E2b		Trip cost per truck ()				$450	$450	$450	$450	E2b
E2b		Trip cost per gallon E10 ()				$0.05	$0.05	$0.05	$0.05	E2b
E2b	Blending	Fuel cost associated with in-truck blending:								E2b
E2b		Gasoline price @ rack (/gal gasoline)				$0.89	$0.89	$0.89	$0.89	E2b
E2b		Added cost/gal for gasoline volatility a				$0.02	$0.02	$0.02	$0.02	E2b
E2b		Cost of 0.90 gal gasoline				$0.81	$0.81	$0.81	$0.81	E2b
E2b		Savings of -.90 gal of alcohol				($0.80)	($1.87)	($0.70)	($1.70)	E2b
E2b		Total cost of E10 fuel delivered to refueling statio				$0.96	$1.08	$0.95	$1.06	E2b
E2b		Delivered cost with wholesale transaction tax (/g E				$0.96	$1.08	$0.95	$1.06	E2b
E2b	Retailing	Total retail margin with low-level ethanol blend compatibility:								E2b
E2b		Total cost (materials and installation)				$0	$1,000	$0	$1,000	E2b
E2b		CRF (10% DR)				0.117	0.117	0.117	0.117	E2b
E2b		Assumed annual throughput (1000 g				953	953	953	953	E2b
E2b		Annualized capital cost (/gal E10)				$0.00	$0.00	$0.00	$0.00	E2b
E2b		Transaction Cost Margin				$0.03	$0.03	$0.03	$0.03	E2b
E2b		Additional Cost Margin				$0.03	$0.03	$0.03	$0.03	E2b
E2b		Total Retail Margin				$0.06	$0.06	$0.06	$0.06	E2b
E2b		Total cost of E10 fuel at the pump (/gal E10)				$1.02	$1.14	$1.01	$1.12	E2b
E2b	Fuel taxes	Federal, state, and local fuel taxes:								E2b
E2b		Federal excise tax (/gal)				$0.09	$0.09	$0.09	$0.09	E2b
E2b		State fuel tax (/gal)				$0.16	$0.16	$0.16	$0.16	E2b
E2b		City and County of Honolulu fuel tax(				$0.17	$0.17	$0.17	$0.17	E2b
E2b		Federal energy tax (/gal)				$0.04	$0.04	$0.04	$0.04	E2b
E2b		Total taxes (/gal E10)				$0.46	$0.46	$0.46	$0.46	E2b
E2b		Total cost after fuel taxes at station (/gal E10)				$1.48	$1.60	$1.46	$1.58	E2b
E2b	Sales tax	Plus state excise tax on retail sales				$1.48	$1.60	$1.46	$1.58	E2b
E2b										E2b
E2b	**Total cost of E10 fuel at the pump(/gal gasoline equivale**					**$1.53**	**$1.65**	**$1.52**	**$1.63**	E2b
E2b	E2b	E2b	E2b	E2b	E2b	E2b	E2b	E2b	E2b	E2b

Scenario E3a

Ethanol (1 and 3 million gpy) from Molasses, Shipped to Oahu, Sold as E85 (E3a)

Annual demand/supply (10^6 gpy E100) (1)	1
Assumed plant size (mgpy) (1)	1
Annual demand/supply (10^6 gpy E100) (2)	3
Assumed plant size (mgpy) (2)	3
Feedstock	Molasses
Risk estimate (compared to cellulosic ethanol)	0.75
Feedstock price/ton (low)	$47
Feedstock price/ton (high)	$47
Plant Gate FOB Price (/gal E100) (1)(low)	$1.17
Plant Gate FOB Price (/gal E100) (1)(high)	$1.17
Plant Gate FOB Price (/gal E100) (2)(low)	$1.08
Plant Gate FOB Price (/gal E100) (2)(high)	$1.08
Number of refueling stations (1)	6
Number of refueling stations (2)	18
Round trip mileage (low)	100
Round trip mileage (high)	200
Average trip speed (mph)	30
Time to load/unload (hours)	1
Terminal (e.g. Hilo) cost/gal E100 (1)(low)	$0.52
Terminal (e.g. Hilo) cost/gal E100 (1)(high)	$0.69
Terminal (e.g. Hilo) cost/gal E100 (2)(low)	$0.15
Terminal (e.g. Hilo) cost/gal E100 (2)(high)	$0.21
Barging cost/gal (low)	$0.04
Barging cost/gal (high)	$0.05
Terminal (e.g. Barbers Pt.) cost/gal E100 (1)(low)	$0.56
Terminal (e.g. Barbers Pt.) cost/gal E100 (1)(high)	$0.80
Terminal (e.g. Barbers Pt.) cost/gal E100 (2)(low)	$0.17
Terminal (e.g. Barbers Pt.) cost/gal E100 (2)(high)	$0.24

INPUTS FOR ALCOHOL SCENARIOS

(Note: some information is used in more than one scenario.)

E3a E3a E3a E3a E3a E3a E3a E3a E3a E3a E3a

	COST CATEGORY	ASSUMPTIONS AND FUEL COST ELEMENTS	COST ESTIMATES low	COST ESTIMATES high	COST ESTIMATES low	COST ESTIMATES high	
E3a	Parameters	Annual demand/supply (10^6 gpy E100)	1	1	3	3	E3a
E3a		Feedstock	Molasses	Molasses	Molasses	Molasses	E3a
E3a		Assumed plant size (mgpy)	1	1	3	3	E3a
E3a		Number of refueling stations	6	6	18	18	E3a
E3a		Annual throughput per station (1000 gal E85)	200	200	200	200	E3a
E3a		Annual demand/supply (10^6 gpy E85)	1	1	4	4	E3a
E3a	Plant gate p	Feedstock price (/ton)	$47	$47	$47	$47	E3a
E3a		Plant Gate FOB Price (/gal E100)	$1.17	$1.17	$1.08	$1.08	E3a
E3a		Company assumed profitable?	yes	no	yes	no	E3a
E3a		Federal business income tax rate	35%	35%	35%	35%	E3a
E3a		Biomass alcohol fuel credit after taxes (/gal E100	$0.00	$0.00	$0.00	$0.00	E3a
E3a		Plant gate price after tax credit	$1.17	$1.17	$1.08	$1.08	E3a
E3a		Small producer credit (/gal E100)	($0.10)	$0.00	($0.10)	$0.00	E3a
E3a		FOB price including small producer's credit (/gal	$1.07	$1.17	$0.98	$1.08	E3a
E3a		Plus wholesale transaction tax	$1.07	$1.18	$0.99	$1.09	E3a
E3a	Transport t	Tank truck capacity (gal)	8,500	8,500	8,500	8,500	E3a
E3a	terminal via	Tank truck (loaded rate/hr)	$150	$150	$150	$150	E3a
E3a	truck	Round trip mileage	100	200	100	200	E3a
E3a		Total hours per round trip including loading and u	4	7	4	7	E3a
E3a		Total transport cost (/gal)	$0.07	$0.12	$0.07	$0.12	E3a
E3a		Total cost delivered to terminal (/gal E100)	$1.15	$1.30	$1.06	$1.21	E3a
E3a	Terminalling	Storage at harbor (Hilo); barging to Oahu:					E3a
E3a	and shipping	Terminal cost (/gal)	$0.52	$0.69	$0.15	$0.21	E3a
E3a		Barging cost - bulk transport (/gal):	$0.04	$0.05	$0.04	$0.05	E3a
E3a		Total landed cost (/gal E100)	$1.70	$2.04	$1.25	$1.47	E3a
E3a	Terminalling	Terminalling + Trucking (Oahu):					E3a
E3a	Trucking from	Terminal cost (/gal E100)	$0.56	$0.80	$0.17	$0.24	E3a
E3a	Rack to Station	Trucking cost (/gal E85)	$0.05	$0.05	$0.05	$0.05	E3a
E3a	Blending	Labor and fuel cost associated with blending:					E3a
E3a		Gasoline rack price (/gal gasoline)	$0.89	$0.89	$0.89	$0.89	E3a
E3a		Cost of 0.15 gal gasoline	$0.13	$0.13	$0.13	$0.13	E3a
E3a		Savings of -.15 gal of alcohol	($0.34)	($0.43)	($0.21)	($0.26)	E3a
E3a		Total cost of ethanol to refueling station (/gal E85	$2.11	$2.60	$1.39	$1.64	E3a
E3a		Delivered cost with wholesale transaction tax (/g	$2.12	$2.61	$1.40	$1.64	E3a
E3a	Retailing	Retail margin with new ethanol facility installation:					E3a
E3a		Total cost (materials and installation)	$0	$103,000	$0	$103,000	E3a
E3a		Cost after tax deduction (28.65% tota	$0	$86,568	$0	$86,568	E3a
E3a		CRF (10% DR, 20 yr life)	0.117	0.117	0.117	0.117	E3a
E3a		Annual throughput of E85 (1000 gal)	200	200	200	200	E3a
E3a		Annualized capital cost (/gal)	$0.00	$0.05	$0.00	$0.05	E3a
E3a		Transaction Cost Margin	$0.03	$0.03	$0.03	$0.03	E3a
E3a		Additional Cost Margin	$0.03	$0.03	$0.03	$0.03	E3a
E3a		Total Retail Margin	$0.06	$0.11	$0.06	$0.11	E3a
E3a		Total cost of E85 fuel at the pump (/gal)	$2.18	$2.71	$1.46	$1.75	E3a
E3a	Fuel taxes	Federal, state, and local fuel taxes:					E3a
E3a		Federal excise tax (/gal)	$0.09	$0.09	$0.09	$0.09	E3a
E3a		State fuel tax (/gal)	$0.16	$0.16	$0.16	$0.16	E3a
E3a		City and County of Honolulu fuel tax	$0.17	$0.17	$0.17	$0.17	E3a
E3a		Federal energy tax (/gal)	$0.04	$0.04	$0.04	$0.04	E3a
E3a		Total taxes (/gal E85)	$0.45	$0.45	$0.45	$0.45	E3a
E3a		Total cost after fuel taxes at station (/gal E85)	$2.64	$3.16	$1.91	$2.20	E3a
E3a	Sales tax	Plus state excise tax on retail sales	$2.64	$3.16	$1.91	$2.20	E3a
E3a	**Total cost of E85 fuel at the pump(/gal gasoline equivale**		**$3.68**	**$4.41**	**$2.67**	**$3.07**	E3a

E3a E3a E3a E3a E3a E3a E3a E3a E3a E3a E3a

.nwtx	E3a.nwtx	E3a.nwtx	E3a.nwtx	E3a.nwtx	E3a.nwtx	E3a.nwtx	E3a.nwtx	E3a.nwtx	E3a.nwtx	E3a.n
.nwtx	COST	ASSUMPTIONS AND FUEL COST ELEMENTS				COST ESTIMATES		COST ESTIMATES		E3a.n
.nwtx	CATEGORY					low	high	low	high	E3a.n
.nwtx	Parameters	Annual demand/supply (10^6 gpy E100)				1.00	1.00	3.00	3.00	E3a.n
.nwtx		Feedstock				Molasses	Molasses	Molasses	Molasses	E3a.n
.nwtx		Assumed plant size (mgpy)				1.00	1.00	3.00	3.00	E3a.n
.nwtx		Number of refueling stations				5.89	5.89	17.67	17.67	E3a.n
.nwtx		Annual throughput per station (1000 gal E85)				200.00	200.00	200.00	200.00	E3a.n
.nwtx		Annual demand/supply (10^6 gpy E85)				1.18	1.18	3.53	3.53	E3a.n
.nwtx	Plant gate p	Feedstock price (/ton)				47.20	47.20	47.20	47.20	E3a.n
.nwtx		Plant Gate FOB Price (/gal E100)				1.17	1.17	1.08	1.08	E3a.n
.nwtx		Company assumed profitable?				yes	no	yes	no	E3a.n
.nwtx		Federal business income tax rate				0.35	0.35	0.35	0.35	E3a.n
.nwtx		Biomass alcohol fuel credit after taxes (/gal E100				0.00	0.00	0.00	0.00	E3a.n
.nwtx		Plant gate price after tax credit				1.17	1.17	1.08	1.08	E3a.n
.nwtx		Small producer credit (/gal E100)				-0.10	0.00	-0.10	0.00	E3a.n
.nwtx		FOB price including small producer's credit (/gal				1.07	1.17	0.98	1.08	E3a.n
.nwtx		Plus wholesale transaction tax				1.07	1.18	0.99	1.09	E3a.n
.nwtx	Transport t	Tank truck capacity (gal)				8500.00	8500.00	8500.00	8500.00	E3a.n
.nwtx	terminal via	Tank truck (loaded rate/hr)				150.00	150.00	150.00	150.00	E3a.n
.nwtx	truck	Round trip mileage				100.00	200.00	100.00	200.00	E3a.n
.nwtx		Total hours per round trip including loading and u				4.00	7.00	4.00	7.00	E3a.n
.nwtx		Total transport cost (/gal)				0.07	0.12	0.07	0.12	E3a.n
.nwtx		Total cost delivered to terminal (/gal E100)				1.15	1.30	1.06	1.21	E3a.n
.nwtx	Terminallin	Storage at harbor (Hilo); barging to Oahu:								E3a.n
.nwtx	and shipping		Terminal cost (/gal)			0.52	0.69	0.15	0.21	E3a.n
.nwtx			Barging cost - bulk transport (/gal):			0.04	0.05	0.04	0.05	E3a.n
.nwtx		Total landed cost (/gal E100)				1.70	2.04	1.25	1.47	E3a.n
.nwtx	Terminallin	Terminalling + Trucking (Oahu):								E3a.n
.nwtx	Trucking from		Terminal cost (/gal E100)			0.56	0.80	0.17	0.24	E3a.n
.nwtx	Rack to Station		Trucking cost (/gal E85)			0.05	0.05	0.05	0.05	E3a.n
.nwtx	Blending	Labor and fuel cost associated with blending:								E3a.n
.nwtx			Gasoline rack price (/gal gasoline)			0.89	0.89	0.89	0.89	E3a.n
.nwtx			Cost of 0.15 gal gasoline			0.13	0.13	0.13	0.13	E3a.n
.nwtx			Savings of -.15 gal of alcohol			-0.34	-0.43	-0.21	-0.26	E3a.n
.nwtx		Total cost of ethanol to refueling station (/gal E85				2.11	2.60	1.39	1.64	E3a.n
.nwtx		Delivered cost with wholesale transaction tax (/g				2.12	2.61	1.40	1.64	E3a.n
.nwtx	Retailing	Retail margin with new ethanol facility installation:								E3a.n
.nwtx			Total cost (materials and installation)			0.00	103000.00	0.00	103000.00	E3a.n
.nwtx			Cost after tax deduction (28.65% tot			0.00	86567.55	0.00	86567.55	E3a.n
.nwtx			CRF (10% DR, 20 yr life)			0.12	0.12	0.12	0.12	E3a.n
.nwtx			Annual throughput of E85 (1000 gal)			200.00	200.00	200.00	200.00	E3a.n
.nwtx			Annualized capital cost (/gal)			0.00	0.05	0.00	0.05	E3a.n
.nwtx			Transaction Cost Margin			0.03	0.03	0.03	0.03	E3a.n
.nwtx			Additional Cost Margin			0.03	0.03	0.03	0.03	E3a.n
.nwtx		Total Retail Margin				0.06	0.11	0.06	0.11	E3a.n
.nwtx		Total cost of E85 fuel at the pump (/gal)				2.18	2.71	1.46	1.75	E3a.n
.nwtx	Fuel taxes	Federal, state, and local fuel taxes:								E3a.n
.nwtx			Federal excise tax (/gal)			0.09	0.09	0.09	0.09	E3a.n
.nwtx			State fuel tax (/gal)			0.10	0.10	0.10	0.10	E3a.n
.nwtx			City and County of Honolulu fuel tax			0.11	0.11	0.11	0.11	E3a.n
.nwtx			Federal energy tax (/gal)			0.04	0.04	0.04	0.04	E3a.n
.nwtx		Total taxes (/gal E85)				0.34	0.34	0.34	0.34	E3a.n
.nwtx		Total cost after fuel taxes at station (/gal E85)				2.52	3.05	1.80	2.09	E3a.nv
.nwtx	Sales tax	Plus state excise tax on retail sales				2.52	3.05	1.80	2.09	E3a.nv
.nwtx										E3a.nv
.nwtx	Total cost of E85 fuel at the pump(/gal gasoline equivalent)					3.52	4.25	2.51	2.91	E3a.nv
.nwtx	E3a.nwtx	E3a.nwtx	E3a.nwtx	E3a.nwtx	E3a.nwtx	E3a.nwtx	E3a.nwtx	E3a.nwtx	E3a.nwtx	E3a.nv

Scenario E3b	
Ethanol (1 and 3 million gpy) from Molasses, Shipped to Oahu, Sold as E10 (E3b)	
Annual demand/supply (10^6 gpy E100) (1)	1
Assumed plant size (mgpy) (1)	1
Annual demand/supply (10^6 gpy E100) (2)	3
Assumed plant size (mgpy) (2)	3
Feedstock	Molasses
Feedstock price/ton (low)	$47
Feedstock price/ton (high)	$47
Plant Gate FOB Price (/gal E100) (1)(low)	$1.17
Plant Gate FOB Price (/gal E100) (1)(high)	$1.17
Plant Gate FOB Price (/gal E100) (2)(low)	$1.08
Plant Gate FOB Price (/gal E100) (2)(high)	$1.08
Number of refueling stations (1)	11
Number of refueling stations (2)	32

INPUTS FOR ALCOHOL SCENARIOS

(Note: some information is used in more than one scenario.)

E3b	E3b	E3b E3b E3b E3b	E3b	E3b	E3b	E3b	E3b
E3b	COST	ASSUMPTIONS AND FUEL COST ELEMENTS	COST ESTIMATES		COST ESTIMATES		E3b
E3b	CATEGORY		low	high	low	high	E3b
E3b	Parameters	Annual demand/supply (10^6 gpy E100)	1	1	3	3	E3b
E3b		Feedstock	Molasses	Molasses	Molasses	Molasses	E3b
E3b		Assumed plant size (mgpy)	1	1	3	3	E3b
E3b		Number of refueling stations	11	11	32	32	E3b
E3b		Annual throughput per station (1000 gal E10)	953	953	953	953	E3b
E3b	Plant gate p	Feedstock price (/ton)	47	47	47	47	E3b
E3b		Plant Gate FOB Price (/gal E100)	$1.17	$1.17	$1.08	$1.08	E3b
E3b		Company assumed profitable?	yes	no	yes	no	E3b
E3b		Federal business income tax rate	35%	35%	35%	35%	E3b
E3b		Small producer credit (/gal E100)	($0.10)	$0.00	($0.10)	$0.00	E3b
E3b		FOB price including small producer's credit (/gal	$1.07	$1.17	$0.98	$1.08	E3b
E3b		Plus wholesale transaction tax	$1.07	$1.18	$0.99	$1.09	E3b
E3b	Transport tc	Tank truck capacity (gal)	8,500	8,500	8,500	8,500	E3b
E3b	terminal via	Tank truck (loaded rate/hr)	$150	$150	$150	$150	E3b
E3b	truck	Round trip mileage	100	200	100	200	E3b
E3b		Total hours per round trip including loading and u	4	7	4	7	E3b
E3b		Total transport cost (/gal)	$0.07	$0.12	$0.07	$0.12	E3b
E3b		Total cost delivered to terminal (/gal E100)	$1.15	$1.30	$1.06	$1.21	E3b
E3b	Terminalling	Storage at harbor (Hilo); barging to Oahu:					E3b
E3b	and shipping	Terminal cost (/gal)	$0.52	$0.69	$0.15	$0.21	E3b
E3b		Barging cost - bulk transport (/gal):	$0.04	$0.05	$0.04	$0.05	E3b
E3b		Total landed cost (/gal E100)	$1.70	$2.04	$1.25	$1.47	E3b
E3b	Terminalling	Terminalling + Trucking (Oahu):					E3b
E3b	Trucking	Terminal cost (/gal E100)	$0.56	$0.80	$0.17	$0.24	E3b
E3b	Rack to Station	Trucking cost (/gal E10)	$0.05	$0.05	$0.05	$0.05	E3b
E3b	Blending	Fuel cost associated with in-truck blending:					E3b
E3b		Gasoline price @ rack (/gal gasoline)	$0.89	$0.89	$0.89	$0.89	E3b
E3b		Added cost/gal for gasoline volatility a	$0.02	$0.02	$0.02	$0.02	E3b
E3b		Cost of 0.90 gal gasoline	$0.81	$0.81	$0.81	$0.81	E3b
E3b		Savings of -.90 gal of alcohol	($2.04)	($2.55)	($1.28)	($1.54)	E3b
E3b		Total cost of E10 fuel delivered to refueling statio	$1.09	$1.15	$1.01	$1.04	E3b
E3b		Delivered cost with wholesale transaction tax (/g E	$1.10	$1.16	$1.01	$1.04	E3b
E3b	Retailing	Total retail margin with low-level ethanol blend compatibility:					E3b
E3b		Total cost (materials and installation)	$0	$1,000	$0	$1,000	E3b
E3b		CRF (10% DR)	0.117	0.117	0.117	0.117	E3b
E3b		Assumed annual throughput (1000 g	953	953	953	953	E3b
E3b		Annualized capital cost (/gal E10)	$0.00	$0.00	$0.00	$0.00	E3b
E3b		Transaction Cost Margin	$0.03	$0.03	$0.03	$0.03	E3b
E3b		Additional Cost Margin	$0.03	$0.03	$0.03	$0.03	E3b
E3b		Total Retail Margin	$0.06	$0.06	$0.06	$0.06	E3b
E3b		Total cost of E10 fuel at the pump (/gal E10)	$1.16	$1.22	$1.07	$1.10	E3b
E3b	Fuel taxes	Federal, state, and local fuel taxes:					E3b
E3b		Federal excise tax (/gal)	$0.09	$0.09	$0.09	$0.09	E3b
E3b		State fuel tax (/gal)	$0.16	$0.16	$0.16	$0.16	E3b
E3b		City and County of Honolulu fuel tax(	$0.17	$0.17	$0.17	$0.17	E3b
E3b		Federal energy tax (/gal)	$0.04	$0.04	$0.04	$0.04	E3b
E3b		Total taxes (/gal E10)	$0.46	$0.46	$0.46	$0.46	E3b
E3b		Total cost after fuel taxes at station (/gal E10)	$1.61	$1.67	$1.53	$1.56	E3b
E3b	Sales tax	Plus state excise tax on retail sales	$1.61	$1.67	$1.53	$1.56	E3b
E3b	**Total cost of E10 fuel at the pump(/gal gasoline equivale**		**$1.67**	**$1.73**	**$1.58**	**$1.61**	E3b
E3b	E3b	E3b E3b E3b E3b	E3b	E3b	E3b	E3b	E3b

Scenario E4a	
Ethanol (7 and 30 million gpy) from Sugarcane on Oahu, Sold as E85 (E4a)	
Annual demand/supply (10^6 gpy E100) (1)	7
Assumed plant size (mgpy) (1)	7
Annual demand/supply (10^6 gpy E100) (2)	30
Assumed plant size (mgpy) (2)	30
Feedstock	Sugarcane
Feedstock price/ton (low)	$38
Feedstock price/ton (high)	$110
Plant Gate FOB Price (/gal E100) (1)(low)	$1.28
Plant Gate FOB Price (/gal E100) (1)(high)	$2.57
Plant Gate FOB Price (/gal E100) (2)(low)	$1.12
Plant Gate FOB Price (/gal E100) (2)(high)	$2.38
Number of refueling stations (1)	41
Number of refueling stations (2)	176

INPUTS FOR ALCOHOL SCENARIOS

(Note: some information is used in more than one scenario.)

E4a	E4a	E4a E4a E4a E4a	E4a	E4a	E4a	E4a	E4a
E4a	COST	ASSUMPTIONS AND FUEL COST ELEMENTS	COST ESTIMATES		COST ESTIMATES		E4a
E4a	CATEGORY		low	high	low	high	E4a
E4a	Parameters	Annual demand/supply (10^6 gpy E100)	7	7	30	30	E4a
E4a		Feedstock	Sugarcane	Sugarcane	Sugarcane	Sugarcane	E4a
E4a		Assumed plant size (mgpy)	7	7	30	30	E4a
E4a		Number of refueling stations	41	41	176	176	E4a
E4a		Annual throughput per station (1000 gal E85)	200	200	200	200	E4a
E4a		Annual demand/supply (10^6 gpy E85)	8	8	35	35	E4a
E4a	Plant gate p	Feedstock price (/ton)	$38	$110	$38	$110	E4a
E4a		Plant Gate FOB Price (/gal E100)	$1.28	$2.57	$1.12	$2.38	E4a
E4a		Company assumed profitable?	yes	no	yes	no	E4a
E4a		Federal business income tax rate	35%	35%	35%	35%	E4a
E4a		Biomass alcohol fuel credit after taxes (/gal E100	$0.00	$0.00	$0.00	$0.00	E4a
E4a		Plant gate price after tax credit	$1.28	$2.57	$1.12	$2.38	E4a
E4a		Small producer credit (/gal E100)	($0.10)	$0.00	($0.05)	$0.00	E4a
E4a		FOB price including small producer's credit (/gal	$1.18	$2.57	$1.07	$2.38	E4a
E4a		Plus wholesale transaction tax	$1.18	$2.58	$1.07	$2.40	E4a
E4a	Truck	Tank truck to terminal, then to plant					E4a
E4a	Transport	Loaded labor rate (/hr)	$150	$150	$150	$150	E4a
E4a	Stations	Number of stations serviced per truc	1	1	1	1	E4a
E4a		Assumed time to take on gasoline at	-	-	-	-	E4a
E4a		ethanol at plant and unload at station (hrs)	3	3	3	3	E4a
E4a		Trip cost per truck	$450	$450	$450	$450	E4a
E4a		Trip cost per gallon E85	$0.05	$0.05	$0.05	$0.05	E4a
E4a	Blending	Fuel cost associated with in-truck blending:					E4a
E4a		Gasoline price @ rack (/gal gasoline)	$0.89	$0.89	$0.89	$0.89	E4a
E4a		Cost of 0.15 gal gasoline	$0.13	$0.13	$0.13	$0.13	E4a
E4a		Savings of -.15 gal of alcohol	($0.18)	($0.39)	($0.16)	($0.36)	E4a
E4a		Total cost of E85 fuel delivered to refueling statio	$1.19	$2.38	$1.10	$2.22	E4a
E4a		Delivered cost with wholesale transaction tax (/g E	$1.20	$2.39	$1.10	$2.23	E4a
E4a	Retailing	Total retail margin with new ethanol facility installation:					E4a
E4a		Total cost (materials and installation)	$0	$103,000	$0	$103,000	E4a
E4a		Cost after tax deduction (28.65% tota	$0	$86,568	$0	$86,568	E4a
E4a		CRF (10% DR, 20 yr life)	0.117	0.117	0.117	0.117	E4a
E4a		Assumed annual throughput (1000 g	200	200	200	200	E4a
E4a		Annualized capital cost (/gal E85)	$0.00	$0.05	$0.00	$0.05	E4a
E4a		Transaction Cost Margin	$0.03	$0.03	$0.03	$0.03	E4a
E4a		Additional Cost Margin (see Appendi	$0.03	$0.03	$0.03	$0.03	E4a
E4a		Total Retail Margin	$0.06	$0.11	$0.06	$0.11	E4a
E4a		Total cost of E85 fuel at the pump (/gal E85)	$1.26	$2.50	$1.16	$2.34	E4a
E4a	Fuel taxes	Federal, state, and local fuel taxes:					E4a
E4a		Federal excise tax (/gal)	$0.09	$0.09	$0.09	$0.09	E4a
E4a		State fuel tax (/gal)	$0.16	$0.16	$0.16	$0.16	E4a
E4a		City and County of Honolulu fuel tax (	$0.17	$0.17	$0.17	$0.17	E4a
E4a		Federal energy tax (/gal)	$0.04	$0.04	$0.04	$0.04	E4a
E4a		Total taxes (/gal E85)	$0.45	$0.45	$0.45	$0.45	E4a
E4a		Total cost after fuel taxes at station (/gal E85)	$1.71	$2.96	$1.62	$2.80	E4a
E4a	Sales tax	Plus state excise tax on retail sales	$1.71	$2.96	$1.62	$2.80	E4a
E4a							E4a
E4a	**Total cost of E85 fuel at the pump(/gal gasoline equivale**		**$2.39**	**$4.13**	**$2.25**	**$3.91**	E4a
E4a							E4a
E4a	E4a	E4a E4a E4a E4a	E4a	E4a	E4a	E4a	E4a

a.nwtx	E4a.nwtx	E4a.nwtx	E4a.nwtx	E4a.nwtx	E4a.nwtx	E4a.nwtx	E4a.nwtx	E4a.nwtx	E4a.nwtx	E4a.n
a.nwtx	COST	ASSUMPTIONS AND FUEL COST ELEMENTS				COST ESTIMATES		COST ESTIMATES		E4a.n
a.nwtx	CATEGORY					low	high	low	high	E4a.n
a.nwtx	Parameters	Annual demand/supply (10^6 gpy E100)				7.00	7.00	30.00	30.00	E4a.n
a.nwtx		Feedstock				Sugarcane	Sugarcane	Sugarcane	Sugarcane	E4a.n
a.nwtx		Assumed plant size (mgpy)				7.00	7.00	30.00	30.00	E4a.n
a.nwtx		Number of refueling stations				41.18	41.18	176.47	176.47	E4a.n
a.nwtx		Annual throughput per station (1000 gal E85)				200.00	200.00	200.00	200.00	E4a.n
a.nwtx		Annual demand/supply (10^6 gpy E85)				8.24	8.24	35.29	35.29	E4a.n
a.nwtx	Plant gate p	Feedstock price (/ton)				38.05	110.29	38.05	110.29	E4a.n
a.nwtx		Plant Gate FOB Price (/gal E100)				1.28	2.57	1.12	2.38	E4a.n
a.nwtx		Company assumed profitable?				yes	no	yes	no	E4a.n
a.nwtx		Federal business income tax rate				0.35	0.35	0.35	0.35	E4a.n
a.nwtx		Biomass alcohol fuel credit after taxes (/gal E100				0.00	0.00	0.00	0.00	E4a.n
a.nwtx		Plant gate price after tax credit				1.28	2.57	1.12	2.38	E4a.n
a.nwtx		Small producer credit (/gal E100)				-0.10	0.00	-0.05	0.00	E4a.n
a.nwtx		FOB price including small producer's credit (/gal				1.18	2.57	1.07	2.38	E4a.n
a.nwtx		Plus wholesale transaction tax				1.18	2.58	1.07	2.40	E4a.n
a.nwtx	Truck	Tank truck to terminal, then to plant								E4a.n
a.nwtx	Transport		Loaded labor rate (/hr)			150.00	150.00	150.00	150.00	E4a.n
a.nwtx	Stations		Number of stations serviced per truc			1.00	1.00	1.00	1.00	E4a.n
a.nwtx			Assumed time to take on gasoline at			-	-	-	-	E4a.n
a.nwtx					ethanol at p	3.00	3.00	3.00	3.00	E4a.n
a.nwtx			Trip cost per truck			450.00	450.00	450.00	450.00	E4a.n
a.nwtx		Trip cost per gallon E85				0.05	0.05	0.05	0.05	E4a.n
a.nwtx	Blending	Fuel cost associated with in-truck blending:								E4a.n
a.nwtx			Gasoline price @ rack (/gal gasoline			0.89	0.89	0.89	0.89	E4a.n
a.nwtx			Cost of 0.15 gal gasoline			0.13	0.13	0.13	0.13	E4a.n
a.nwtx			Savings of -.15 gal of alcohol			-0.18	-0.39	-0.16	-0.36	E4a.n
a.nwtx		Total cost of E85 fuel delivered to refueling statio				1.19	2.38	1.10	2.22	E4a.n
a.nwtx		Delivered cost with wholesale transaction tax (/g				1.20	2.39	1.10	2.23	E4a.n
a.nwtx	Retailing	Total retail margin with new ethanol facility install				0.00	0.00	0.00	0.00	E4a.n
a.nwtx			Total cost (materials and installation)			0.00	103000.00	0.00	103000.00	E4a.n
a.nwtx			Cost after tax deduction (28.65% tot			0.00	86567.55	0.00	86567.55	E4a.n
a.nwtx			CRF (10% DR, 20 yr life)			0.12	0.12	0.12	0.12	E4a.n
a.nwtx			Assumed annual throughput (1000 g			200.00	200.00	200.00	200.00	E4a.n
a.nwtx			Annualized capital cost (/gal E85)			0.00	0.05	0.00	0.05	E4a.n
a.nwtx			Transaction Cost Margin			0.03	0.03	0.03	0.03	E4a.n
a.nwtx			Additional Cost Margin (see Appendi			0.03	0.03	0.03	0.03	E4a.n
a.nwtx		Total Retail Margin				0.06	0.11	0.06	0.11	E4a.n
a.nwtx		Total cost of E85 fuel at the pump (/gal E85)				1.26	2.50	1.16	2.34	E4a.n
a.nwtx	Fuel taxes	Federal, state, and local fuel taxes:								E4a.n
a.nwtx			Federal excise tax (/gal)			0.09	0.09	0.09	0.09	E4a.n
a.nwtx			State fuel tax (/gal)			0.10	0.10	0.10	0.10	E4a.n
a.nwtx			City and County of Honolulu fuel tax			0.11	0.11	0.11	0.11	E4a.n
a.nwtx			Federal energy tax (/gal)			0.04	0.04	0.04	0.04	E4a.n
a.nwtx		Total taxes (/gal E85)				0.34	0.34	0.34	0.34	E4a.n
a.nwtx										E4a.n
a.nwtx		Total cost after fuel taxes at station (/gal E85)				1.60	2.84	1.50	2.68	E4a.n
a.nwtx	Sales tax	Plus state excise tax on retail sales				1.60	2.84	1.50	2.68	E4a.n
a.nwtx										E4a.n
a.nwtx	Total cost of E85 fuel at the pump(/gal gasoline equivalent)					2.23	3.97	2.10	3.75	E4a.n
a.nwtx	E4a.nwtx	E4a.nwtx	E4a.nwtx	E4a.nwtx	E4a.nwtx	E4a.nwtx	E4a.nwtx	E4a.nwtx	E4a.nwtx	E4a.n

Scenario E4b

Ethanol (7 and 30 million gpy) Produced from Sugarcane on Oahu, Sold as E10 (E4b)

Annual demand/supply (10^6 gpy E100) (1)	7
Assumed plant size (mgpy) (1)	7
Annual demand/supply (10^6 gpy E100) (2)	30
Assumed plant size (mgpy) (2)	30
Feedstock	Sugarcane
Feedstock price/ton (low)	$38
Feedstock price/ton (high)	$110
Plant Gate FOB Price (/gal E100) (1)(low)	$1.28
Plant Gate FOB Price (/gal E100) (1)(high)	$2.57
Plant Gate FOB Price (/gal E100) (2)(low)	$1.12
Plant Gate FOB Price (/gal E100) (2)(high)	$2.38
Number of refueling stations (1)	73
Number of refueling stations (2)	315

INPUTS FOR ALCOHOL SCENARIOS

(Note: some information is used in more than one scenario.)

E4b	E4b	E4b E4b E4b E4b	E4b	E4b	E4b	E4b	E4b
E4b	COST	ASSUMPTIONS AND FUEL COST ELEMENTS	COST ESTIMATES		COST ESTIMATES		E4b
E4b	CATEGORY		low	high	low	high	E4b
E4b	Parameters	Annual demand/supply (10^6 gpy E100)	7	7	30	30	E4b
E4b		Feedstock	Sugarcane	Sugarcane	Sugarcane	Sugarcane	E4b
E4b		Assumed plant size (mgpy)	7	7	30	30	E4b
E4b		Number of refueling stations	73	73	315	315	E4b
E4b		Annual throughput per station (1000 gal E10)	953	953	953	953	E4b
E4b	Plant gate p	Feedstock price (/ton)	$38	$110	$38	$110	E4b
E4b		Plant Gate FOB Price (/gal E100)	$1.28	$2.57	$1.12	$2.38	E4b
E4b		Company assumed profitable?	yes	no	yes	no	E4b
E4b		Federal business income tax rate	35%	35%	35%	35%	E4b
E4b		Small producer credit (/gal E100)	($0.10)	$0.00	($0.05)	$0.00	E4b
E4b		FOB price including small producer's credit (/gal	$1.18	$2.57	$1.07	$2.38	E4b
E4b		Plus wholesale transaction tax	$1.18	$2.58	$1.07	$2.40	E4b
E4b	Truck	Tank truck to terminal, then to plant					E4b
E4b	Transport to	Loaded labor rate (/hr)	$150	$150	$150	$150	E4b
E4b	Stations	Number of stations serviced per truc	1	1	1	1	E4b
E4b		Assumed time to take on gasoline at	-	-	-	-	E4b
E4b		ethanol at plant and unload at station (hrs)	3	3	3	3	E4b
E4b		Trip cost per truck ()	$450	$450	$450	$450	E4b
E4b		Trip cost per gallon E10 ()	$0.05	$0.05	$0.05	$0.05	E4b
E4b	Blending	Fuel cost associated with in-truck blending:					E4b
E4b		Gasoline price @ rack (/gal gasoline)	$0.89	$0.89	$0.89	$0.89	E4b
E4b		Added cost for RVP reduction (/gal)	$0.02	$0.02	$0.02	$0.02	E4b
E4b		Cost of 0.90 gal gasoline	$0.81	$0.81	$0.81	$0.81	E4b
E4b		Savings of -.90 gal of alcohol	($1.07)	($2.32)	($0.96)	($2.16)	E4b
E4b		Total cost of E10 fuel delivered to refueling statio	$0.99	$1.13	$0.97	$1.11	E4b
E4b		Delivered cost with wholesale transaction tax (/g E	$0.99	$1.13	$0.98	$1.11	E4b
E4b	Retailing	Total retail margin with low-level ethanol blend compatibility:					E4b
E4b		Total cost (materials and installation)	$0	$1,000	$0	$1,000	E4b
E4b		CRF (10% DR)	0.117	0.117	0.117	0.117	E4b
E4b		Assumed annual throughput (1000 g	953	953	953	953	E4b
E4b		Annualized capital cost (/gal E10)	$0.00	$0.00	$0.00	$0.00	E4b
E4b		Transaction Cost Margin	$0.03	$0.03	$0.03	$0.03	E4b
E4b		Additional Cost Margin	$0.03	$0.03	$0.03	$0.03	E4b
E4b		Total Retail Margin	$0.06	$0.06	$0.06	$0.06	E4b
E4b		Total cost of E10 fuel at the pump (/gal E10)	$1.05	$1.19	$1.04	$1.17	E4b
E4b	Fuel taxes	Federal, state, and local fuel taxes:					E4b
E4b		Federal excise tax (/gal)	$0.09	$0.09	$0.09	$0.09	E4b
E4b		State fuel tax (/gal)	$0.16	$0.16	$0.16	$0.16	E4b
E4b		City and County of Honolulu fuel tax(	$0.17	$0.17	$0.17	$0.17	E4b
E4b		Federal energy tax (/gal)	$0.04	$0.04	$0.04	$0.04	E4b
E4b		Total taxes (/gal E10)	$0.46	$0.46	$0.46	$0.46	E4b
E4b		Total cost after fuel taxes at station (/gal E10)	$1.51	$1.65	$1.49	$1.63	E4b
E4b	Sales tax	Plus state excise tax on retail sales	$1.51	$1.65	$1.49	$1.63	E4b
E4b	**Total cost of E10 fuel at the pump(/gal gasoline equivale**		**$1.56**	**$1.70**	**$1.55**	**$1.68**	E4b
E4b	E4b	E4b E4b E4b E4b	E4b	E4b	E4b	E4b	E4b

Scenario E5	
Ethanol (60 and 100 million gpy) from Neighbor Island Sugarcane, Shipped to Oahu, Sold as E85 (E5)	
Annual demand/supply (10^6 gallons E100) (1)	60
Assumed plant size (mgpy) (1)	30
Annual demand/supply (10^6 gallons E100) (2)	100
Assumed plant size (mgpy) (2)	50
Feedstock	Sugarcane
Feedstock price/ton (low)	$38
Feedstock price/ton (high)	$110
Plant Gate FOB Price (/gal) (1)(low)	$1.12
Plant Gate FOB Price (/gal) (1)(high)	$2.38
Plant Gate FOB Price (/gal) (2)(low)	$1.07
Plant Gate FOB Price (/gal) (2)(high)	$2.34
Number of refueling stations (1)	353
Number of refueling stations (2)	400
Terminal (e.g. Hilo) cost/gal E100 (1)(low)	$0.01
Terminal (e.g. Hilo) cost/gal E100 (1)(high)	$0.02
Terminal (e.g. Hilo) cost/gal E100 (2)(low)	$0.01
Terminal (e.g. Hilo) cost/gal E100 (2)(high)	$0.01
Barging cost/gal (low)	$0.04
Barging cost/gal (high)	$0.05
Terminal (e.g. Barbers Pt.) cost/gal E100 (1)(low)	$0.01
Terminal (e.g. Barbers Pt.) cost/gal E100 (1)(high)	$0.02
Terminal (e.g. Barbers Pt.) cost/gal E100 (2)(low)	$0.01
Terminal (e.g. Barbers Pt.) cost/gal E100 (2)(high)	$0.01

INPUTS FOR ALCOHOL SCENARIOS

(Note: some information is used in more than one scenario.)

E5	E5	E5 E5 E5 E5	E5	E5	E5	E5	E5
E5	COST	ASSUMPTIONS AND FUEL COST ELEMENTS	COST ESTIMATES		COST ESTIMATES		E5
E5	CATEGORY		low	high	low	high	E5
E5	Parameters	Annual demand/supply (10^6 gallons E100)	**60**	**60**	**100**	**100**	E5
E5		Feedstock	Sugarcane	Sugarcane	Sugarcane	Sugarcane	E5
E5		Assumed plant size (mgpy)	30	30	50	50	E5
E5		Number of refueling stations	353	353	400	400	E5
E5		Annual throughput per station (1000 gal E85)	200	200	294	294	E5
E5		Annual demand/supply (10^6 gpy E85)	71	71	118	118	E5
E5	Plant gate p	Feedstock price (/ton)	$38	$110	$38	$110	E5
E5		Plant Gate FOB Price (/gal)	$1.12	$2.38	$1.07	$2.34	E5
E5		Company assumed profitable?	yes	no	yes	no	E5
E5		Federal business income tax rate	35%	35%	35%	35%	E5
E5		Biomass alcohol fuel credit after taxes (/gal E100	$0.00	$0.00	$0.00	$0.00	E5
E5		Plant gate price after tax credit	$1.12	$2.38	$1.07	$2.34	E5
E5		Small producer credit (/gal E100)	($0.05)	$0.00	$0.00	$0.00	E5
E5		FOB price including small producer's credit (/gal	$1.07	$2.38	$1.07	$2.34	E5
E5		Plus wholesale transaction tax	$1.07	$2.40	$1.08	$2.35	E5
E5	Transport t	Tank truck capacity (gal)	8,500	8,500	8,500	8,500	E5
E5	terminal via	Tank truck (loaded rate/hr)	$150	$150	$150	$150	E5
E5	truck	Round trip mileage	100	200	100	200	E5
E5		Total hours per round trip including loading and u	4	7	4	7	E5
E5		Total transport cost (/gal)	$0.07	$0.12	$0.07	$0.12	E5
E5		Total cost delivered to terminal (/gal E100)	$1.14	$2.52	$1.15	$2.47	E5
E5	Terminallin	Storage at harbor (Hilo); barging to Oahu:					E5
E5	and shipping	Terminal cost (/gal)	$0.01	$0.02	$0.01	$0.01	E5
E5		Barging cost - bulk transport (/gal):	$0.04	$0.05	$0.04	$0.05	E5
E5		Total landed cost (/gal E100)	$1.19	$2.59	$1.19	$2.53	E5
E5	Terminallin	Terminalling + Trucking (Oahu):					E5
E5	Trucking from	Terminal cost (/gal E100)	$0.01	$0.02	$0.01	$0.01	E5
E5	Rack to Station	Trucking cost (/gal E85)	$0.05	$0.05	$0.05	$0.05	E5
E5	Blending	Labor and fuel cost associated with blending:					E5
E5		Gasoline rack price (/gal gasoline)	$0.89	$0.89	$0.89	$0.89	E5
E5		Cost of 0.15 gal gasoline	$0.13	$0.13	$0.13	$0.13	E5
E5		Savings of -.15 gal of alcohol	($0.18)	($0.39)	($0.18)	($0.38)	E5
E5		Total cost of ethanol to refueling station (/gal E85	$1.21	$2.40	$1.21	$2.35	E5
E5		Delivered cost with wholesale transaction tax (/g	$1.22	$2.41	$1.21	$2.36	E5
E5	Retailing	Retail margin with new ethanol facility installation:					E5
E5		Total cost (materials and installation)	$0	$103,000	$0	$103,000	E5
E5		Cost after tax deduction (28.65% tot	$0	$86,568	$0	$86,568	E5
E5		CRF (10% DR, 20 yr life)	0.117	0.117	0.117	0.117	E5
E5		Annual throughput of E85 (1000 gal)	200	200	294	294	E5
E5		Annualized capital cost (/gal)	$0.00	$0.05	$0.00	$0.03	E5
E5		Transaction Cost Margin	$0.03	$0.03	$0.03	$0.03	E5
E5		Additional Cost Margin	$0.03	$0.03	$0.03	$0.03	E5
E5		Total Retail Margin	$0.06	$0.11	$0.06	$0.09	E5
E5		Total cost of E85 fuel at the pump (/gal)	$1.28	$2.51	$1.27	$2.44	E5
E5	Fuel taxes	Federal, state, and local fuel taxes:					E5
E5		Federal excise tax (/gal)	$0.09	$0.09	$0.09	$0.09	E5
E5		State fuel tax (/gal)	$0.16	$0.16	$0.16	$0.16	E5
E5		City and County of Honolulu fuel tax	$0.17	$0.17	$0.17	$0.17	E5
E5		Federal energy tax (/gal)	$0.04	$0.04	$0.04	$0.04	E5
E5		Total taxes (/gal E85)	$0.45	$0.45	$0.45	$0.45	E5
E5		Total cost after fuel taxes at station (/gal E85)	$1.73	$2.96	$1.73	$2.89	E5
E5	Sales tax	Plus state excise tax on retail sales	$1.73	$2.96	$1.73	$2.89	E5
E5	**Total cost of E85 fuel at the pump(/gal gasoline equivale**		**$2.42**	**$4.14**	**$2.41**	**$4.04**	E5
E5	E5	E5 E5 E5 E5	E5	E5	E5	E5	E5

.nwtx	E5 .nwtx	E5 .nwtx	E5 .nwtx	E5 .nwtx	E5 .nwtx	E5 .nwtx	E5 .nwtx	E5 .nwtx	E5 .nwtx	E5 .n
.nwtx	COST	ASSUMPTIONS AND FUEL COST ELEMENTS				COST ESTIMATES		COST ESTIMATES		E5 .n
.nwtx	CATEGORY					low	high	low	high	E5 .n
.nwtx	Parameters	Annual demand/supply (10^6 gallons E100)				60.00	60.00	100.00	100.00	E5 .n
.nwtx		Feedstock				Sugarcane	Sugarcane	Sugarcane	Sugarcane	E5 .n
.nwtx		Assumed plant size (mgpy)				30.00	30.00	50.00	50.00	E5 .n
.nwtx		Number of refueling stations				352.94	352.94	400.00	400.00	E5 .n
.nwtx		Annual throughput per station (1000 gal E85)				200.00	200.00	294.12	294.12	E5 .n
.nwtx		Annual demand/supply (10^6 gpy E85)				70.59	70.59	117.65	117.65	E5 .n
.nwtx	Plant gate p	Feedstock price (/ton)				38.05	110.29	38.05	110.29	E5 .n
.nwtx		Plant Gate FOB Price (/gal)				1.12	2.38	1.07	2.34	E5 .n
.nwtx		Company assumed profitable?				yes	no	yes	no	E5 .n
.nwtx		Federal business income tax rate				0.35	0.35	0.35	0.35	E5 .n
.nwtx		Biomass alcohol fuel credit after taxes (/gal E100				0.00	0.00	0.00	0.00	E5 .n
.nwtx		Plant gate price after tax credit				1.12	2.38	1.07	2.34	E5 .n
.nwtx		Small producer credit (/gal E100)				-0.05	0.00	0.00	0.00	E5 .n
.nwtx		FOB price including small producer's credit (/gal				1.07	2.38	1.07	2.34	E5 .n
.nwtx		Plus wholesale transaction tax				1.07	2.40	1.08	2.35	E5 .n
.nwtx	Transport tc	Tank truck capacity (gal)				8500.00	8500.00	8500.00	8500.00	E5 .n
.nwtx	terminal via	Tank truck (loaded rate/hr)				150.00	150.00	150.00	150.00	E5 .n
.nwtx	truck	Round trip mileage				100.00	200.00	100.00	200.00	E5 .n
.nwtx		Total hours per round trip including loading and u				4.00	7.00	4.00	7.00	E5 .n
.nwtx		Total transport cost (/gal)				0.07	0.12	0.07	0.12	E5 .n
.nwtx		Total cost delivered to terminal (/gal E100)				1.14	2.52	1.15	2.47	E5 .n
.nwtx	Terminalling	Storage at harbor (Hilo); barging to Oahu:								E5 .n
.nwtx	and shipping		Terminal cost (/gal)			0.01	0.02	0.01	0.01	E5 .n
.nwtx			Barging cost - bulk transport (/gal):			0.04	0.05	0.04	0.05	E5 .n
.nwtx		Total landed cost (/gal E100)				1.19	2.59	1.19	2.53	E5 .n
.nwtx	Terminalling	Terminalling + Trucking (Oahu):								E5 .n
.nwtx	Trucking from		Terminal cost (/gal E100)			0.01	0.02	0.01	0.01	E5 .n
.nwtx	Rack to Station		Trucking cost (/gal E85)			0.05	0.05	0.05	0.05	E5 .n
.nwtx	Blending	Labor and fuel cost associated with blending:								E5 .n
.nwtx			Gasoline rack price (/gal gasoline)			0.89	0.89	0.89	0.89	E5 .n
.nwtx			Cost of 0.15 gal gasoline			0.13	0.13	0.13	0.13	E5 .n
.nwtx			Savings of -.15 gal of alcohol			-0.18	-0.39	-0.18	-0.38	E5 .n
.nwtx		Total cost of ethanol to refueling station (/gal E85				1.21	2.40	1.21	2.35	E5 .n
.nwtx		Delivered cost with wholesale transaction tax (/g				1.22	2.41	1.21	2.36	E5 .n
.nwtx	Retailing	Retail margin with new ethanol facility installation:								E5 .n
.nwtx			Total cost (materials and installation)			0.00	103000.00	0.00	103000.00	E5 .n
.nwtx			Cost after tax deduction (28.65% tot			0.00	86567.55	0.00	86567.55	E5 .n
.nwtx			CRF (10% DR, 20 yr life)			0.12	0.12	0.12	0.12	E5 .n
.nwtx			Annual throughput of E85 (1000 gal)			200.00	200.00	294.12	294.12	E5 .n
.nwtx			Annualized capital cost (/gal)			0.00	0.05	0.00	0.03	E5 .n
.nwtx			Transaction Cost Margin			0.03	0.03	0.03	0.03	E5 .n
.nwtx			Additional Cost Margin			0.03	0.03	0.03	0.03	E5 .n
.nwtx		Total Retail Margin				0.06	0.11	0.06	0.09	E5 .n
.nwtx		Total cost of E85 fuel at the pump (/gal)				1.28	2.51	1.27	2.44	E5 .n
.nwtx	Fuel taxes	Federal, state, and local fuel taxes:								E5 .n
.nwtx			Federal excise tax (/gal)			0.09	0.09	0.09	0.09	E5 .n
.nwtx			State fuel tax (/gal)			0.10	0.10	0.10	0.10	E5 .n
.nwtx			City and County of Honolulu fuel tax			0.11	0.11	0.11	0.11	E5 .n
.nwtx			Federal energy tax (/gal)			0.04	0.04	0.04	0.04	E5 .n
.nwtx		Total taxes (/gal E85)				0.34	0.34	0.34	0.34	E5 .n
.nwtx		Total cost after fuel taxes at station, (/gal E85)				1.62	2.85	1.61	2.78	E5 .n
.nwtx	Sales tax	Plus state excise tax on retail sales				1.62	2.85	1.61	2.78	E5 .n
.nwtx										E5 .n
.nwtx	Total cost of E85 fuel at the pump(/gal gasoline equivalent)					2.26	3.98	2.25	3.88	E5 .nv
.nwtx	E5 .nwtx	E5 .nwtx	E5 .nwtx	E5 .nwtx	E5 .nwtx	E5 .nwtx	E5 .nwtx	E5 .nwtx	E5 .nwtx	E5 .nv

APPENDIX A-4

FLOW CHART OF MODEL

INSTRUCTIONS FOR THE ALTERNATIVE TRANSPORTATION FUELS SCENARIO BUILDER

INFORMATION FLOW BETWEEN SPREADSHEETS

RESULTS OF EVALUATIONS OF INDIVIDUAL MEASURES

RESULTS OF EVALUATIONS OF GROUPS OF MEASURES

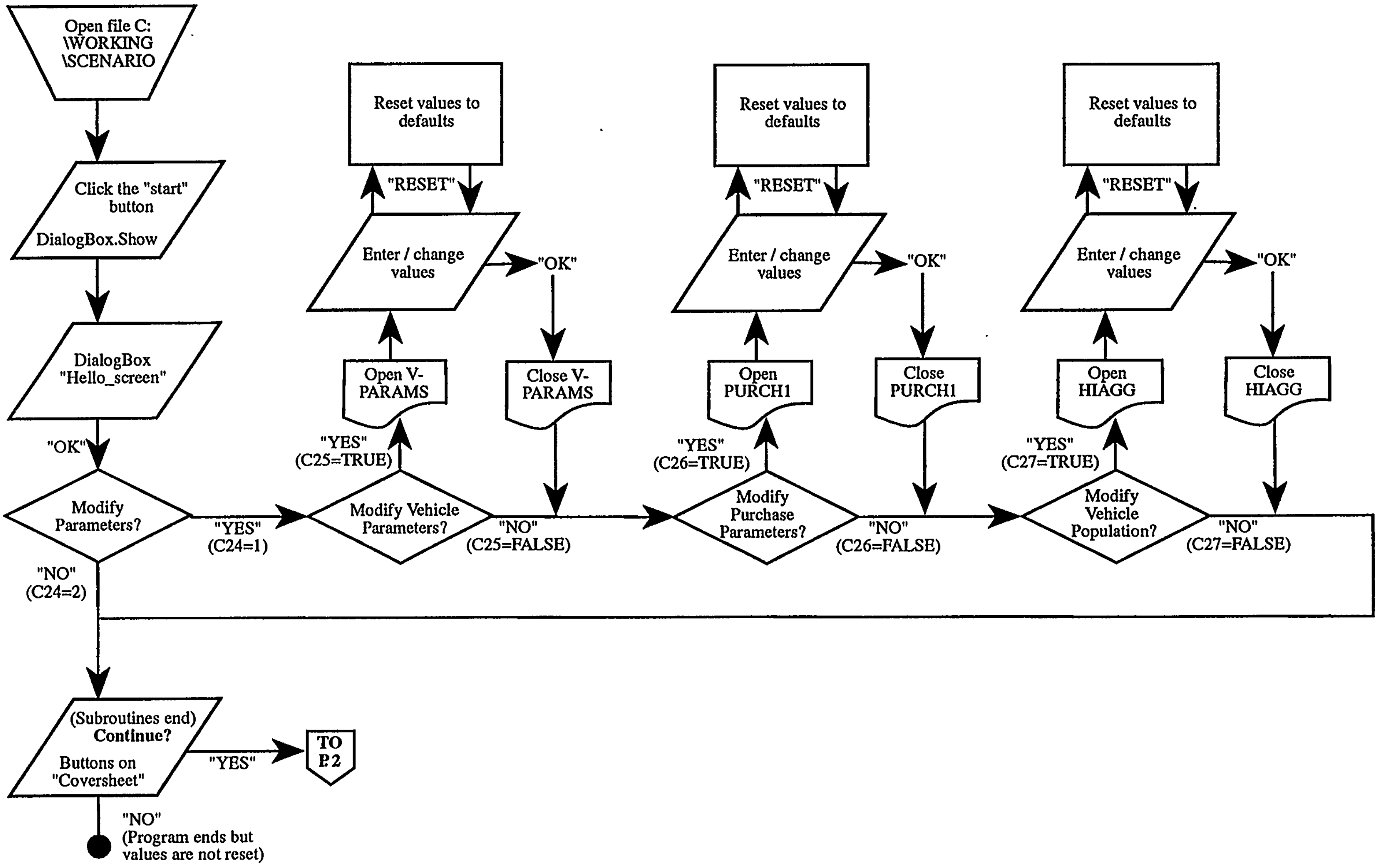
SAMPLE DETAIL FROM AN EVALUATION RUN

FLOW CHART OF MODEL

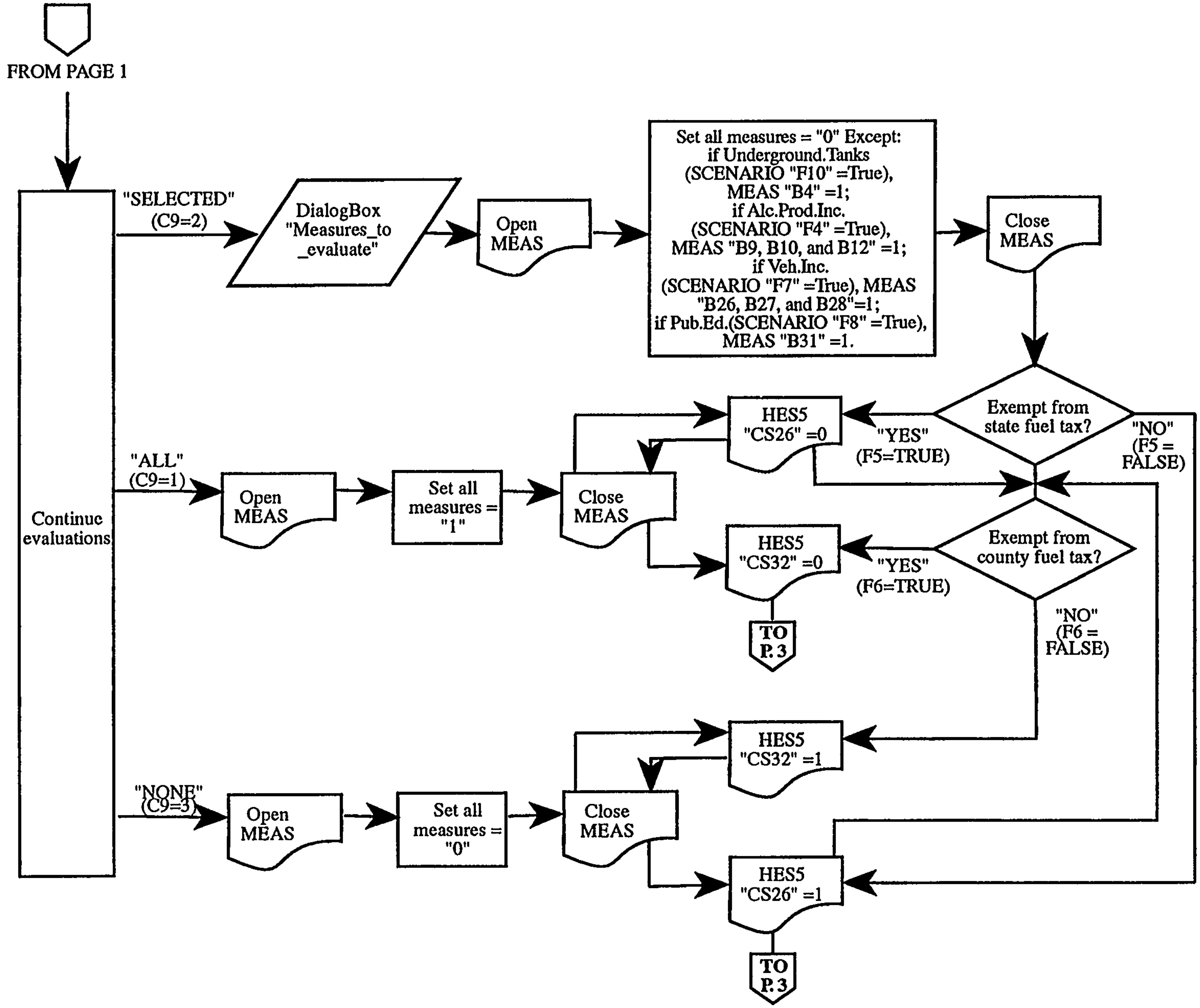
(APPENDIX A-4)

PAGE 1

Last update: 6/25/95

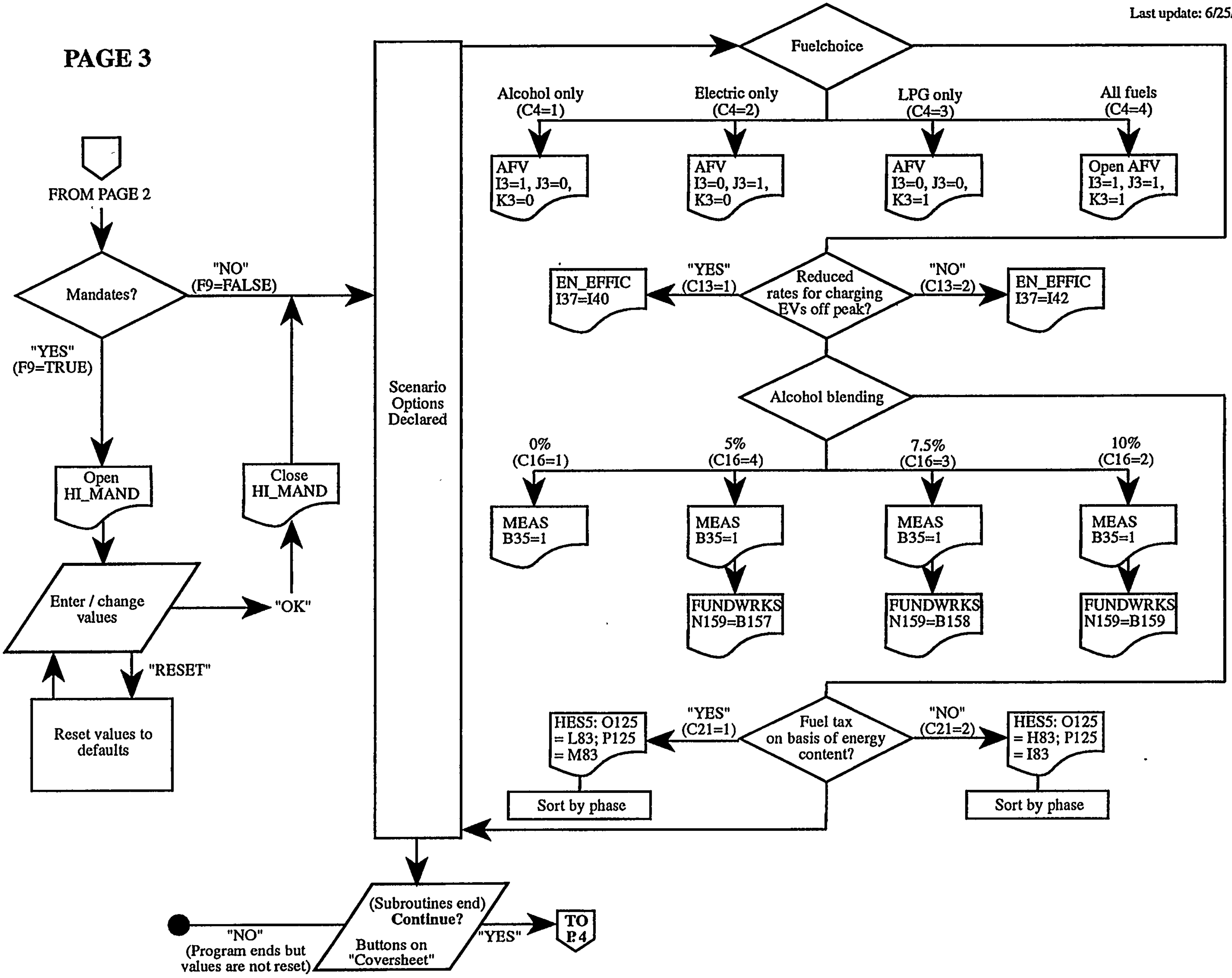


PAGE 2


FROM PAGE 1
Continue evaluations
"SELECTED" (C9=2)
DialogBox "Measures_to _evaluate"
Open MEAS
Set all measures = "0" Except: if Underground.Tanks (SCENARIO "F10" =True), MEAS "B4" =1; if Alc.Prod.Inc. (SCENARIO "F4" =True), MEAS "B9, B10, and B12" =1; if Veh.Inc. (SCENARIO "F7" =True), MEAS "B26, B27, and B28"=1; if Pub.Ed.(SCENARIO "F8" =True), MEAS "B31" =1.
Close MEAS
Exempt from state fuel tax?
"YES" (F5=TRUE)
"NO" (F5 = FALSE)
Exempt from county fuel tax?
"YES" (F6=TRUE)
"NO" (F6 = FALSE)
"ALL" (C9=1)
Open MEAS
Set all measures = "1"
Close MEAS
HES5 "CS26" =0
HES5 "CS32" =0
TO P. 3
"NONE" (C9=3)
Open MEAS
Set all measures = "0"
Close MEAS
HES5 "CS32" =1
HES5 "CS26" =1
TO P. 3

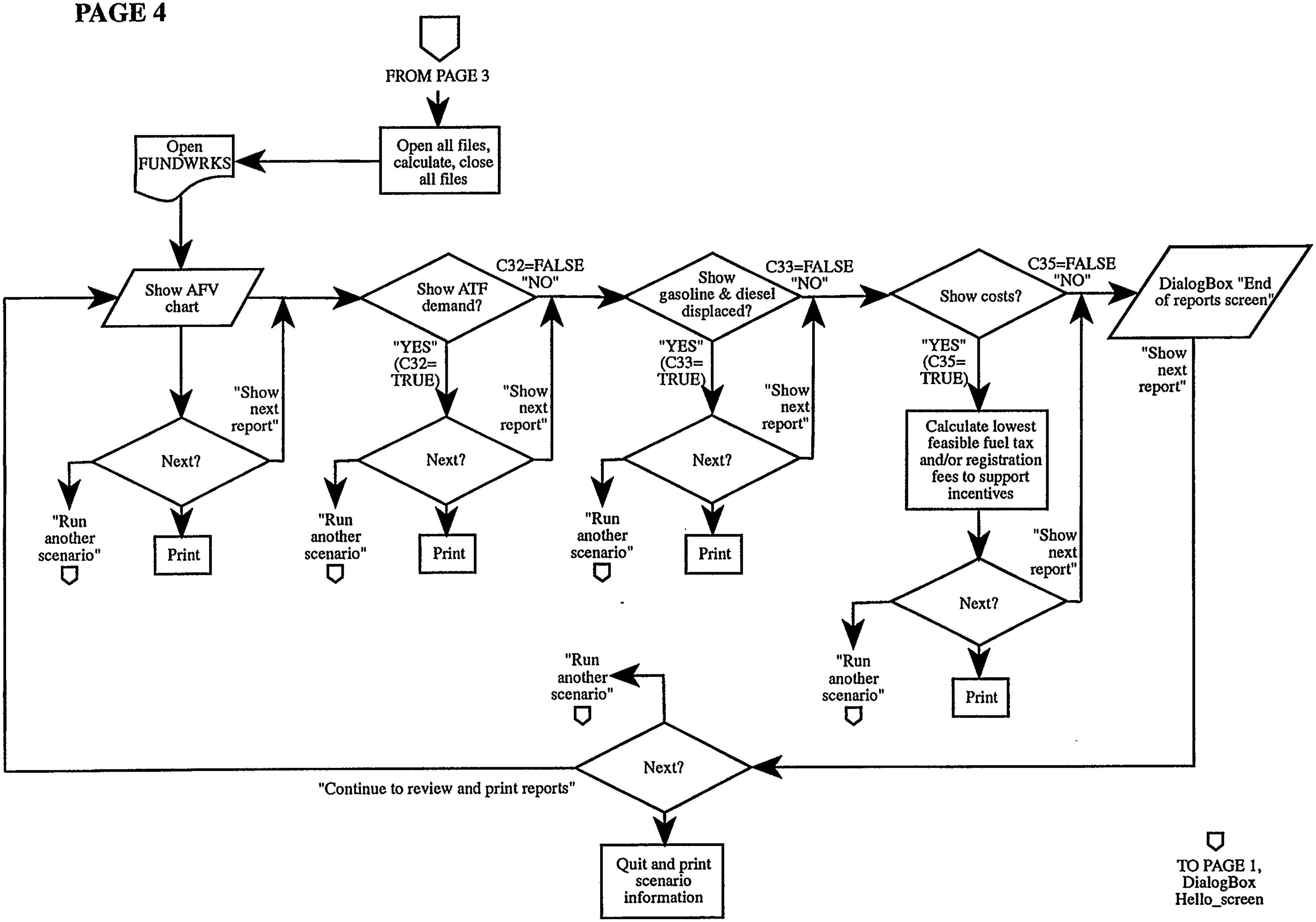
Last update: 6/25/95

PAGE 3



Last update: 6/25/95

PAGE 4



INSTRUCTIONS FOR THE ALTERNATIVE TRANSPORTATION FUELS SCENARIO BUILDER

(APPENDIX A-4 cont'd)

INSTRUCTIONS
FOR
THE ALTERNATIVE TRANSPORTATION FUELS SCENARIO BUILDER

PURPOSE

The Alternative Transportation Fuels Scenario Builder was developed for in-house use in **estimating** the impact, effectiveness, costs, etc. of various policies or measures which have been suggested as possible means of influencing the use of alternative transportation fuels.

As with any first-generation model, refinements and improvements may be added as time and resources permit.

COMPUTER HARDWARE / SOFTWARE REQUIREMENTS

The model runs in Microsoft Excel, version 5.0, and is comprised of discrete sections which are integrated via an Excel workbook named "SCENARIO.XLS." The twenty-two files fit on five high-density floppy diskettes. The minimum memory (RAM) sufficient to run the model has not been determined, but the model has been run successfully on a PC running under Windows with 8 MB of RAM.

INSTALLATION

All files should be located in the same directory, named "WORKING," which should not be in any other subdirectories (i.e. C:/WORKING/*.*).

USE

Open the application "Microsoft Excel" (version 5.0 or later).

From the File menu, select "open." Go up to the folder **c:** and click "OK." Scroll all the way to the bottom of the list of folders, select the folder named "**WORKING**," and click "OK." Scroll down the list of files, select the file named "**SCENARIO.XLS**," and click "OK."

When asked, "This document contains links. Re-establish links?" Select "NO."

A "welcome" screen will appear. Click on the START button when ready.

Note: Use the above procedure every time. DO NOT try to open SCENARIO.XLS from the list of "recent documents." (Although the file will open, the directory path may not be set properly.)

- ### Beginning the scenario run

The first screen asks for several selections:

Fuels

Choices:	alcohol only, electric only, LPG only, or all fuels simultaneously.
Comment:	select "all fuels simultaneously." The other options are for testing purposes only.
Recommended:	"all fuels simultaneously."

Measures to evaluate

Choices:	all proposed incentives and mandates, selected incentives and mandates, no incentives or mandates.
Comment:	if "selected incentives and mandates" is chosen, you will (in a later screen) have an opportunity to indicate which incentives or mandates to include in the scenario.
Recommended:	"selected incentives and mandates."

Reduced rates for charging electric vehicles (EVs) off-peak

Choices:	yes or no.
Comment:	if "yes" is selected, the electricity price used for EV recharging is the HECO rate schedule "U," time-of-use service; if "no" is selected, the electricity price used for EV recharging is the HECO rate schedule "R," residential service.
Recommended:	"yes."

Alcohol blending in gasoline

Choices:	0%, 5%, 7.5%, 10%.
Comment:	the percentage selected is applied to the projected gasoline demand remaining after the alternative fueled vehicles have been taken into account.

Alcohol blending in diesel

Choices:	0%, 5%, 10%, 30%.
Comment:	the percentage selected is applied to the projected diesel demand remaining after the alternative fueled vehicles have been taken into account.

Fuel tax on the basis of energy content?

Choices:	yes or no.
Comment:	if "yes" is selected, state and county fuel taxes are adjusted to account for the fact that alternative fuels contain less energy per gallon; if "no" is selected, current tax rates are used.

Recommended: "yes."

Modify / view parameters?

Choices:	yes or no; if yes, possibilities are vehicle technology / cost; vehicle population; purchaser bias; and phases / credits.
Comment:	for each parameter to be viewed and/or modified, the user will (at a later screen) have an opportunity to view current settings and to modify them, reset them to defaults, or to make no changes.
Recommended:	"yes" to all.

Reports

Choices:	number of vehicles; quantity of fuel used; gasoline and diesel displaced; costs and employment.
Comment:	choice of reports does not have any effect on the results of the scenario run itself.
Recommended:	all reports.

Scenario Name

Choices:	User-entered.
Comment:	entering a descriptive name for the scenario will help to identify the results. Any combination of letters, numbers, and symbols is acceptable.

The name will automatically be entered into the scenario results storage file (DATAKEEP.XLS) and will become a legend identifying the run when the comparison graph is developed.

If the name is too long it may not fit on the graph. The shorter the better; suggest fewer than 30 characters.

- **Modifying vehicle technology and cost**

  If the "modify / view vehicle technology" option was selected, this screen will appear. (And if you didn't select the "modify / view vehicle technology" option, you can skip this part.)

  This screen allows you to modify the vehicle characteristics of alcohol, electric, and/or propane vehicles. (Gasoline vehicle numbers are for comparison purposes only and do not need to be / cannot be changed here.)

  All costs are in constant dollars.

  These values will remain until they are selected again and changed by the user.

  Recommended: "Reset to Defaults."

- **Modifying purchaser bias**

  If the "modify / view purchaser bias" option was selected, this screen will appear.

  This screen allows you to adjust for differences in perception between Hawaii and California, since the vehicle purchase portion of the model is based on stated purchase preferences from California.

  These values will remain until they are selected again and changed by the user.

  Recommended: "Reset to Defaults."

- **Modifying vehicle population parameters**

  If the "modify / view vehicle population" option was selected, this screen will appear.

  This screen allows you to adjust the average annual rate of vehicle population increase. The default rate (2.02%) is based on the increase in vehicle miles traveled that was projected in the state and county transportation plans, prepared in the late 1980s, which provided the baseline for the Transportation Energy Strategy project.

  You will also be able to change the "percent of vehicles resold in-state as used vehicles."

  These values will remain until they are selected again and changed by the user.

  Recommended: "Reset to Defaults."

- **Modifying phases / credits**

  If the "modify phases / credits" option was selected, this screen will appear.

  This screen allows you to adjust the phases, incentive amounts, and phase-out schedules for the credits. The default rate, when used with other default elements, roughly corresponds to vehicle population numbers of demonstration (phase 1), fleet use (phase 2), transition (phase 3), maturing (phase 4) and mature (phase 5).

These values will remain until they are selected again and changed by the user.

Recommended: "Reset to Defaults."

- **CONTINUATION CHECK #1**

  This is just an escape point (and/or shortcut re-entry point) for advanced users. If you are ready to continue, click the "continue" button.

- **Measures to evaluate**

  If the "selected incentives and mandates" option was selected, this screen will appear. Any combination of incentives and mandates may be selected (remember the name you gave this scenario run in the first screen - choose incentives to match the scenario name).

Fuel incentives

Choices: local producers of alcohol fuels receive production incentive; alternative fuels exempt from state highway taxes; alternative fuels exempt from county highway taxes.

Comment: choosing a fuel incentive automatically includes an increased tax on gasoline and diesel to provide the necessary funding for the fuel incentive measure(s).

Vehicle incentives / mandates

Choices: Purchasers of alternative fuel vehicles receive purchase incentive; state government fleets purchase AFVs; State law mandates private fleet purchase of alternative fuel vehicles.

Comment: choosing a vehicle purchase incentive automatically includes a surcharge on gasoline and diesel-fueled vehicles to provide the necessary funding for the fuel incentive.

General

Choices: public and private organizations cooperate to increase public awareness of alternative fuels; new or replacement fuel tanks (specifically, underground retail service station storage tanks) are double-walled stainless steel.

Comment: both of these measures are generally under way, although the rate or extent to which these measures are occurring may vary with location and circumstances.

Recommended: public and private organizations cooperate to increase public awareness of alternative fuels; new or replacement fuel tanks are double-walled stainless steel (run with both boxes checked).

Fleet mandates

If you selected an option which includes private fleet mandates, this screen will appear.

This screen allows you to adjust percentage requirements for rental and private (non-rental) fleets. For your information, percentage requirements in the National Energy Policy Act of 1992 (EPACT) are also shown on this screen.

Recommended: "Reset to Defaults."

CONTINUATION CHECK #2

This is another escape point. If you are ready to continue, click the "continue" button.

Your scenario run is complete!

Your scenario has been calculated successfully. To view results, select "view."

Projected number of alternative fuel vehicles (AFVs)

This is the first view of the results. Select "print" or "show next report."

Selecting print will print three graphs - projected number of alternative fuel vehicles, projected fuel demand for all ground transportation fuels on a gasoline-equivalent gallon (GEG) basis, and projected demand for alternative fuels only.

Projected use of alternative transportation fuels

This is a tabular report of the actual gallons and/or kWh of alternative fuels projected. For an explanation of the difference between "actual gallons" and gasoline-equivalent gallons (GEG), see the Transportation Energy Strategy Project final report.

Gasoline and diesel displaced by alternative fuels

This is a tabular report of the projected demand by the ground transportation sector in the State of Hawaii for gasoline-equivalent gallons (GEG) of conventional and alternative fuels.

Cost

If the numbers in the second column (Additional costs ..to motorists (additional fuel taxes and / or vehicle registration fees) are greater than $0, additional calculations are necessary to make sure that funds into the program and funds out of the program are balanced. If those calculations are necessary, the column will be highlighted in yellow and instructions will be shown on the screen.

If instructed to do so, click the "Optimize Costs" button. If asked any questions, just hit "ENTER" on your keyboard.

- You may get a message saying, "SOLVER.XLA is already open. Reopening will cause your changes to be discarded. Do you want to reopen?" Don't panic, this is perfectly OK. Select "Yes."
- After some calculations, you may get a message that the maximum time has expired. Select "Continue."
- You will get a "Solver Results" screen. Whether or not Solver thinks it has found a solution, Select "OK." (Yes, "Keep solver results.")
- After more calculations, you may get a message that the maximum time has expired. Select "Continue."
- You'll get a second "Solver Results" screen. Whether or not Solver thinks it has found a solution, Select "OK." (Yes, "Keep solver results.")
- Finally, you'll be returned to the "Cost" screen, where (now that everything has been balanced out) you can go ahead and "print" or show next report.

If you select "Print," it will print out the cost screen and several additional pages of detail.

End of scenario run

Selecting "Continue to review and print reports" will send you back to the reports you have just seen, in case you want to take another look, print out, or forgot to optimize the costs.

Selecting "Return to Welcome screen" will first send a set of results to an excel file named "DATAKEEP.XLS." You will then be taken back to the first screen, where you will be able to print out your scenario parameters before starting the next run.

When a set of scenario runs is completed

When all scenario runs are completed, you may see the results compared to each other. At the "Welcome" screen, select the button, "finished - compare results."

When asked what you want to name your comparison, use standard file naming conventions (up to 8 letters, etc.) IF YOU GET ANY KIND OF WARNING MESSAGES, DO NOT CONTINUE (i.e. select "NO" or "QUIT" or "ESCAPE") - you don't want to accidentally overwrite something.

Data from your runs will be saved to a file with the name you chose, and graphs containing comparisons will be generated. You will be able to view, change, and print them using standard Excel commands. When finished, select the "DONE" button above the graphs and you will be back at the now-familiar "Welcome" screen. (Where you may start a whole new set of scenario runs, if you want to.)

Since the runs will be together on the graphs, and too many runs together make differentiating between them difficult, it is suggested that runs be done in batches of not more than ten (i.e. not more than ten runs per graph; five is preferable).

Finished for the day

Select "close" from the File menu.

When asked if you want to save changes to SCENARIO.XLS, select "NO."

Select "exit" from the File Menu.

INFORMATION FLOW BETWEEN SPREADSHEETS

(APPENDIX A-4 cont'd)

INFORMATION FLOW BETWEEN SPREADSHEETS

FUEL COSTS

Fuel production costs (ethanol and methanol only)

Methanol fuel production costs are calculated in METH.XLS, using inputs of feedstock cost and facility size from HES5.XLS.

Ethanol fuel production costs are calculated in BIOY.XLS (ethanol from sugarcane, 2 scales of facility) and MOL.XLS (ethanol from solid waste, 2 scales of facility, and ethanol from molasses, 2 scales of facility). Facility scales for molasses and solid waste are constrained by the amount of material available on any one island; information on organic waste is provided by ORGW.XLS. MOL.XLS obtains parameters such as interest and depreciation rates from HES5.XLS and forwards them to BIOY.XLS.

Transportation and infrastructure costs

Transportation and infrastructure costs are combined with the various alcohol production evaluations to give a total of 30 alcohol fuel scenarios, each with a "low" and a "high" price-at-the-pump cost estimate.

Taxes

Federal, state, and local taxes for gasoline, diesel, and the various alternative fuels are contained in HES5.XLS. The "proposed" state and county fuel tax rates (adjusted on the basis of energy content) are calculated separately; pump prices using taxes adjusted on the basis of energy content may replace price-at-the-pump cost estimates using conventional taxes by running SCENARIO.XLS.

NUMBER OF ALTERNATIVE FUEL VEHICLES

Voluntary purchases of alternative fuel vehicles.

Voluntary purchases are estimated based on vehicle characteristics (vehicle cost, fuel cost, top speed, range, acceleration, cargo space, service station availability, service station refueling time, home recharge availability and recharging time) compared against a baseline gasoline vehicle. Since vehicle characteristics are projected to change over time, the user may enter the assumed vehicle characteristics for certain years into VEHICLES.XLS. The relative attractiveness of each vehicle type, based on vehicle characteristics from VEHICLES.XLS, is calculated in PURCHASE.XLS. For each year, vehicle price for non-government purchasers is adjusted to reflect any vehicle purchase incentives proposed in FUNDWRKS.XLS. Also, since sensitivity to price is income-dependent, purchases are estimated for each income level. The resulting purchase estimates are combined by AFV.XLS, assuming AFV availability rates and a diffusion time which is dependent upon public awareness levels (time for diffusion is obtained from FUNDWRKS.XLS, with and without public awareness efforts as stated in MEAS.XLS). Resultant voluntary purchases are provided to HI_VOL.XLS.

Federally-mandated purchases of alternative fuel vehicles.

Although a federal mandate (e.g. the National Energy Policy Act of 1992) may require that a certain percentage of new vehicles in affected fleets shall be alternatively fueled, the choice of what mix of alternative fuel vehicles to purchase is expected to be similar to the mix calculated for voluntary purchases in each phase. First, the numbers of vehicles required for each type of fleet are determined in HI_FED.XLS; then, the relative mix of alternative fuels is obtained from AFV.XLS and applied to the number of vehicles required, to give a total number of each type of vehicle in HI_FED.XLS.

State-mandated purchases of alternative fuel vehicles.

In SCENARIO.XLS, the user is able to specify whether or not state mandates are included in scenario runs. Percentages for private and rental fleets are user-entered in HI_MAND.XLS. In an approach similar to the federal mandates, the total number of AFVs required is distributed across fuel types based on the relative attractiveness of each fuel.

State government vehicles are assumed to follow the 25% requirement in Administrative Directive 94-06 beginning in 1998 if "state fleet purchase of AFVs" is selected.

Total number of alternative fuel vehicles.

In HIAGG.XLS, the maximum of each of the three possible situations (voluntary, federal mandate, or state mandate) is used to obtain the number of alternative fuel vehicles purchased by the given fleet in the given year. Then, the relative attractiveness of the fuels (from AFV.XLS) is applied to that number, and the total is used in all subsequent calculations, including the sale of vehicles to used vehicle purchasers.

The total number of new vehicles purchased per year may be adjusted in HIAGG.XLS by the user via SCENARIO.XLS. The default value is based on the number of vehicles assumed to be on the road in FUTR-FUE.XLS, which is based on DOT projections used for this study. When vehicle growth rate is changed, the fuel use per vehicle (which includes a congestion factor) also changes. Fewer vehicles on the road would result in less loss of fuel to congestion and therefore lower overall fuel wasted in congestion per vehicle.

TOTAL DEMAND FOR ALTERNATIVE FUELS

Demand from alternative fuel vehicles.

The numbers of alternative fuel vehicles is provided by HIAGG.XLS to FUNDWRKS.XLS, where the number of conventionally-fueled vehicles and demand for the various types of fuels is determined.

Demand from alcohol blending.

Scenarios may be run which include no alcohol blending, 5% blending into gasoline, 7.5% blending into gasoline, and 10% blending into gasoline; and/or 5% blending into diesel, 10% blending into diesel, and 30% blending into diesel. The user-specified amount of blending is entered via SCENARIO.XLS into FUNDWRKS.XLS, and is applied to the amount of gasoline and diesel used by conventionally-fueled vehicles. If the rate of alcohol blending in gasoline is greater than the amount which could be supplied by methanol, the alcohol assumed for blending is ethanol (this information is supplied to HES-5 via SCENARIO.XLS for use in phasing and costing of the scenarios).

REDUCED RATES FOR CHARGING ELECTRIC VEHICLES "OFF-PEAK"

Electric vehicle charging is addresses in EN-EFFIC.XLS via SCENARIO.XLS and the resultant "fuel cost" is used in PURCHASE.XLS.

ADJUST FUEL TAXES ON THE BASIS OF ENERGY CONTENT

This measure is addressed in HES5.XLS via SCENARIO.XLS. (Since adjusting the fuel taxes results in the same net amount into the highway fund per alternative fuel vehicle as for a comparable conventionally-fueled vehicle, this measure is not considered an incentive.)

EVALUATION OF INCENTIVES AND MANDATES

Scenarios may be run with or without various incentives and mandates (listed in MEAS.XLS) via SCENARIO.XLS. Incentives and mandates may also be adjusted (for example, the amounts and phase-outs of purchase incentives may be adjusted directly in FUNDWRKS.XLS).

Special fund for alternative fuel incentives

This measure involves assessing an extra tax on gasoline and diesel fuels and using the revenues to fund alternative fuel subsidies (primarily producer payments for local production of alcohol fuels, although distribution may be changed by restructuring FUNDWRKS.XLS). The amount of subsidy is the difference between the cost per gasoline equivalent gallon (GEG) of the alcohol fuel and the cost per gallon of gasoline. This difference is dependent upon the scale of production and other factors included in the alcohol production scenarios, including taxes, transportation, infrastructure, and feedstock costs. Alcohol scenarios are grouped into "phases" and the average of the minimum low- and minimum high-end cost estimates in each phase is used to estimate the amount of subsidy for that phase. (This occurs in HES5.XLS.) The subsidies remain the same or decrease from one phase to the next. If the measure is active, the subsidy is used to reduce the fuel cost in the PURCHASE.XLS file.

The amount of additional tax is optimized by running the macro *solver_run* in FUNDWRKS.XLS when prompted to do so. If this is not done, program expenditures may exceed program receipts.

Special fund for vehicle incentives

This measure involves assessing an extra fee on gasoline and diesel vehicles and using the revenues to fund incentives for the purchase of alternative fuel vehicles. The incentives are set amounts for light-and heavy-duty alcohol and electric vehicles and are reduced by a certain percentage in each phase. Incentive amounts and phase-outs may be changed in FUNDWRKS.XLS. If the measure is active, the incentive amounts are used to reduce vehicle costs in the PURCHASE.XLS file.

The amount assessed on conventional vehicles is optimized by running the macro *solver_run* in FUNDWRKS.XLS when prompted to do so. If this is not done, program expenditures may exceed program receipts.

Exempt alternative fuels from state and county highway taxes

Although not listed in MEAS.XLS, the effect of this measure may be assessed via SCENARIO.XLS.

MODIFYING ASSUMPTIONS

The assumptions most likely to be revised (i.e. AFV technologies and costs; fleet growth rates) may be modified through SCENARIO.XLS. However, other assumptions may also require modification. To change feedstock costs or other alcohol fuel costs, change the values in HES5.XLS, column T (alcohol scenario input section). To change federal (or other) fuel tax rates, go to HES5.XLS, range CO9:CS22. To change rack price of gasoline, go to HES5.XLS, cell CR63. To change AFV availability rates, go to AFV.XLS and change the values in columns B (cars) and C (trucks) in the 3 "detail" worksheets. To run the model without EPACT requirements, change the "1" in HIAGG.XLS cell A100 to "0", open STFL.XLS, save and close both, then run SCENARIO.XLS. To change fuel efficiency assumptions for future years, go to FUTR-FUE.XLS, "Argonne" worksheet. Once changes have been made, all spreadsheets should be opened simultaneously and allowed to update.

LINKED TO (SOURCE):

DESTINATION

Filename	AFV.XLS	BIOY.XLS	COUNTIES.XLS	EN-EFFIC.XLS	FUNDWRKS.XLS	FUTR-FUE.XLS	HES5.XLS	HI_FED.XLS	HI_MAND.XLS	HI_VOL.XLS	HIAGG.XLS	MEAS.XLS	METH.XLS	MOL.XLS	ORGW.XLS	PURCHASE.XLS	REGV.XLS	SCENARIO.XLS	STFL.XLS	VEHICLES.XLS	VEH-TYPE.XLS	NONE	
AFV.XLS					X						X					X							AFV.XLS
BIOY.XLS							X																BIOY.XLS
COUNTIES.XLS																						N	COUNTIES.XLS
EN-EFFIC.XLS																						N	EN-EFFIC.XLS
FUNDWRKS.XLS	X						X				X	X					X	X			X		FUNDWRKS.XLS
FUTR-FUE.XLS											X						X						FUTR-FUE.XLS
HES5.XLS		X										X	X	X			X						HES5.XLS
HI_FED.XLS	X										X					X			X				HI_FED.XLS
HI_MAND.XLS	X										X.	X				X		X					HI_MAND.XLS
HI_VOL.XLS	X										X					X							HI_VOL.XLS
HIAGG.XLS	X					X		X	X	X						X	X	X	X		X		HIAGG.XLS
MEAS.XLS																						N	MEAS.XLS
METH.XLS							X																METH.XLS
MOL.XLS		X					X								X								MOL.XLS
ORGW.XLS																						N	ORGW.XLS
PURCHASE.XLS	X			X	X		X				X							X		X	X		PURCHASE.XLS
REGV.XLS							X														X		REGV.XLS
SCENARIO.XLS				X	X				X		X					X				X			SCENARIO.XLS
STFL.XLS											X												STFL.XLS
VEHICLES.XLS					X													X					VEHICLES.XLS
VEH-TYPE.XLS			X								X						X						VEH-TYPE.XLS
	AFV.XLS	BIOY.XLS	COUNTIES.XLS	EN-EFFIC.XLS	FUNDWRKS.XLS	FUTR-FUE.XLS	HES5.XLS	HI_FED.XLS	HI_MAND.XLS	HI_VOL.XLS	HIAGG.XLS	MEAS.XLS	METH.XLS	MOL.XLS	ORGW.XLS	PURCHASE.XLS	REGV.XLS	SCENARIO.XLS	STFL.XLS	VEHICLES.XLS	VEH-TYPE.XLS	NONE	

Note: Save source workbooks before saving dependent workbooks.

LINKED TO (SOURCE):

RESULTS OF EVALUATIONS OF INDIVIDUAL MEASURES

(APPENDIX A-4 cont'd)

R E M A I N I	YEAR	O.1-4 Outreach / Education	A.19 Vehicle Purchase Incentives	A.13c Private Fleet Requirements	A.13a State Fleet 25% AFV Requirement	A.7 Alcohol Fuel Production Incentive	A.6 Adjust Fuel Taxes (Energy Content)	A.3 Diesohol 30%	A.2b Rates for EV Offpeak Charging	A.2a Alcohol-Compatible Fuel Tanks	A.1b Oxygen Content Requirement	A.1a Alcohol Blending 10%	A.1a Alcohol Blending 7.5%	A.1a Alcohol Blending 5%
N	1995	410,980,237	410,980,952	410,980,961	410,980,961	410,980,657	410,980,922	405,462,879	410,980,949	410,980,954	397,984,548	384,540,103	391,319,780	397,984,548
G	1996	416,434,354	416,439,374	415,840,951	416,439,406	416,438,440	416,439,282	410,732,260	416,439,363	416,439,384	403,289,736	389,687,011	396,546,505	403,289,736
	1997	420,934,899	420,956,935	419,355,961	420,957,021	420,954,514	420,956,700	415,070,748	420,956,904	420,956,963	407,683,944	393,954,169	400,877,731	407,683,944
G	1998	425,370,460	425,443,834	422,425,258	425,400,989	425,438,186	425,443,291	419,376,186	425,443,748	425,443,907	412,048,274	398,192,907	405,179,802	412,048,274
A	1999	429,243,582	429,409,745	425,040,961	429,333,296	429,398,983	429,408,724	423,165,380	429,409,539	429,409,900	415,907,762	401,944,204	408,985,656	415,907,762
S	2000	431,019,525	431,363,499	425,279,273	431,263,626	431,343,292	431,361,535	424,969,185	431,362,980	431,363,745	417,817,071	403,811,093	410,873,936	417,817,071
O	2001	432,599,923	433,223,515	425,041,685	433,099,577	433,186,904	433,219,856	426,678,224	433,222,375	433,223,859	419,633,258	405,588,173	412,670,737	419,633,258
L	2002	433,724,673	434,776,695	424,298,359	434,628,259	434,714,008	434,770,397	428,082,314	434,774,561	434,777,270	421,148,969	407,075,005	414,172,133	421,148,969
I	2003	434,442,290	435,949,121	423,038,365	435,775,451	435,859,994	435,941,106	429,120,786	435,945,746	435,949,948	422,303,627	408,212,986	415,318,523	422,303,627
N	2004	434,738,569	436,696,856	420,759,275	436,497,825	436,564,557	436,685,081	429,736,728	436,691,171	436,697,760	423,040,383	408,947,105	416,053,972	423,040,383
E	2005	438,084,266	440,449,769	421,255,894	440,223,492	440,258,832	440,433,101	433,309,400	440,440,903	440,451,006	426,686,041	412,493,442	419,650,394	426,686,041
	2006	441,225,523	443,912,703	421,312,092	443,661,675	443,646,833	443,889,177	436,594,795	443,898,997	443,913,691	430,047,664	415,766,023	422,967,644	430,047,664
&	2007	444,441,571	447,345,196	420,962,066	447,102,407	446,989,670	447,313,278	439,815,598	447,325,223	447,345,655	433,377,352	419,008,821	426,253,655	433,377,352
	2008	448,123,992	451,149,599	420,826,557	450,906,078	450,694,073	451,109,666	443,413,434	451,122,374	451,149,943	437,067,849	422,601,579	429,894,725	437,067,849
D	2009	451,902,333	454,939,316	420,878,456	454,686,543	454,372,827	454,889,362	446,990,392	454,903,993	454,939,375	440,740,803	426,178,552	433,518,727	440,740,803
I	2010	455,760,256	458,700,110	421,131,555	458,434,829	458,015,876	458,636,774	450,532,840	458,652,910	458,696,775	444,383,049	429,726,998	437,112,712	444,383,049
E	2011	459,930,329	462,651,097	421,562,522	462,371,204	461,848,577	462,573,578	454,259,387	462,591,022	462,643,235	448,210,669	433,455,850	440,889,229	448,210,669
S	2012	464,398,216	466,824,594	422,199,313	466,531,435	465,903,897	466,733,394	458,199,368	466,752,748	466,813,289	452,251,912	437,392,363	444,876,080	452,251,912
E	2013	469,175,297	471,269,414	423,278,761	470,962,383	470,237,267	471,165,085	462,401,779	471,186,090	471,254,629	456,557,756	441,585,797	449,124,461	456,557,756
L	2014	474,217,549	475,983,696	424,808,625	475,662,115	474,849,510	475,866,944	468,865,593	475,889,410	475,965,304	461,126,873	446,034,844	453,633,117	461,126,873
		7	13	1	9	8	10	6	11	12	4	2	3	4

	YEAR	O.1-4	A.19	A.13c	A.13a	A.7	A.6	A.3	A.2b	A.2a	A.1b	A.1a (10%)	A.1a (7.5%)	A.1a (5%)
A	1995	8,884	8,545	8,539	8,539	9,616	8,706	5,526,830	8,464	8,570	13,005,305	26,449,750	19,670,072	13,005,305
L	1996	30,934	28,616	296,119	28,598	41,101	30,549	5,738,737	27,787	28,961	13,183,375	26,786,099	19,926,606	13,183,375
C	1997	66,183	56,163	752,431	56,119	84,628	60,538	5,949,109	54,222	56,940	13,340,667	27,070,443	20,146,881	13,340,667
O	1998	132,673	99,771	1,383,039	116,877	154,059	108,040	6,180,019	95,925	101,226	13,516,789	27,372,156	20,385,261	13,516,789
H	1999	433,001	358,415	2,332,898	387,967	551,687	388,191	6,649,950	341,850	363,552	13,940,964	27,904,523	20,863,070	13,940,964
O	2000	775,949	621,163	3,398,498	659,657	959,248	673,982	7,098,267	591,876	631,093	14,308,322	28,314,301	21,251,457	14,308,322
L	2001	1,168,189	889,042	4,624,160	935,753	1,376,233	964,586	7,551,418	845,568	903,029	14,678,442	28,723,527	21,640,962	14,678,442
	2002	1,793,317	1,241,895	6,001,484	1,297,042	1,927,448	1,347,619	8,098,025	1,179,101	1,261,429	15,144,595	29,218,559	22,121,432	15,144,595
	2003	2,538,138	1,775,349	7,536,927	1,842,426	2,646,696	1,904,866	8,761,702	1,687,361	1,801,982	15,731,805	29,822,447	22,716,910	15,731,805
	2004	3,411,442	2,444,588	9,454,443	2,521,354	3,556,388	2,603,050	9,558,118	2,321,274	2,477,677	16,456,422	30,549,700	23,442,834	16,456,422
	2005	4,380,711	3,241,213	11,559,395	3,328,849	4,643,366	3,434,750	10,529,416	3,073,990	3,282,551	17,412,140	31,604,738	24,447,787	17,412,140
	2006	5,432,727	4,159,435	14,153,521	4,259,393	5,908,191	4,397,556	11,624,984	3,942,479	4,213,245	18,497,099	32,777,347	25,577,119	18,497,099
	2007	6,441,240	5,092,465	16,808,820	5,188,369	7,193,172	5,372,642	12,845,331	4,820,362	5,155,897	19,592,289	33,955,936	26,715,985	19,592,289
	2008	7,248,656	5,869,577	19,256,905	5,966,293	8,245,947	6,179,690	13,881,442	5,548,674	5,941,030	20,506,833	34,962,749	27,679,957	20,506,833
	2009	8,010,770	6,653,690	21,553,554	6,754,068	9,309,851	6,993,381	14,927,657	6,281,476	6,732,520	21,426,953	35,971,593	28,649,028	21,426,953
	2010	8,731,466	7,437,610	23,705,075	7,551,130	10,386,888	7,816,714	15,979,905	7,021,274	7,533,414	22,355,107	36,984,665	29,625,444	22,355,107
	2011	9,275,548	8,163,339	25,769,522	8,278,013	11,351,807	8,563,285	16,957,433	7,695,170	8,262,914	23,199,724	37,917,672	30,521,165	23,199,724
	2012	9,691,267	8,751,415	27,720,601	8,866,589	12,186,168	9,178,356	17,845,384	8,237,492	8,855,462	23,948,076	38,759,000	31,323,908	23,948,076
	2013	9,979,993	9,225,115	29,456,443	9,341,900	12,862,290	9,674,613	18,627,100	8,672,980	9,333,461	24,580,511	39,490,824	32,012,135	24,580,511
	2014	10,167,168	9,589,595	30,981,614	9,708,401	13,383,283	10,056,393	19,306,940	9,006,623	9,701,316	25,101,185	40,117,393	32,589,312	25,101,185
		8	12	3	10	7	9	6	13	11	4	1	2	4

	YEAR	O.1-4	A.19	A.13c	A.13a	A.7	A.6	A.3	A.2b	A.2a	A.1b	A.1a Alcohol Blending 10%	A.1a Alcohol Blending 7.5%	A.1a (5%)
E	1995	9,020	8,955	8,947	8,947	8,797	8,922	8,907	9,094	8,942	8,879	8,879	8,879	8,879
L	1996	13,534	13,022	70,584	12,996	11,211	12,709	12,527	14,780	12,942	12,199	12,199	12,199	12,199
E	1997	21,344	18,883	180,850	18,808	14,614	18,139	17,713	23,025	18,683	16,943	16,943	16,943	16,943
C	1998	39,511	30,618	352,345	34,953	22,117	29,108	28,267	38,817	30,180	26,746	26,746	26,746	26,746
T	1999	128,606	111,242	561,696	114,202	69,771	100,151	96,474	140,422	104,853	89,832	89,832	89,832	89,832
R	2000	241,826	202,021	845,418	201,817	124,371	180,259	173,509	253,803	188,886	161,309	161,309	161,309	161,309
I	2001	380,636	298,718	1,189,403	298,935	184,861	267,474	257,525	376,103	280,178	239,529	239,529	239,529	239,529
C	2002	559,597	435,605	1,605,657	430,109	271,097	390,651	376,304	547,664	408,958	350,322	350,322	350,322	350,322
	2003	795,421	605,968	2,099,364	594,041	389,735	546,340	538,787	760,396	568,669	502,085	502,085	502,085	502,085
	2004	1,094,680	836,260	2,760,380	820,095	556,659	762,246	762,885	1,051,199	789,946	712,260	712,260	712,260	712,260
	2005	1,455,290	1,134,496	3,564,248	1,111,521	774,120	1,041,322	1,052,268	1,424,725	1,075,735	984,201	984,201	984,201	984,201
	2006	1,863,858	1,500,139	4,376,036	1,467,155	1,041,202	1,382,839	1,405,282	1,879,820	1,425,467	1,316,436	1,316,865	1,316,436	1,316,436
	2007	2,280,306	1,886,380	5,335,073	1,844,968	1,330,913	1,749,603	1,758,390	2,365,619	1,800,636	1,673,881	1,675,425	1,673,881	1,673,881
	2008	2,656,585	2,248,151	6,325,334	2,201,900	1,613,668	2,097,059	2,095,033	2,818,184	2,154,375	2,016,947	2,020,309	2,016,947	2,016,947
	2009	3,032,650	2,630,647	7,340,360	2,580,682	1,915,437	2,465,114	2,451,733	3,295,157	2,528,800	2,380,789	2,386,665	2,380,789	2,380,789
	2010	3,412,161	3,042,160	8,377,767	2,984,524	2,238,823	2,857,787	2,834,397	3,801,578	2,928,090	2,769,136	2,778,219	2,769,136	2,769,136
	2011	3,755,930	3,405,506	9,368,367	3,362,485	2,546,796	3,226,233	3,193,717	4,272,758	3,301,834	3,136,333	3,149,221	3,136,333	3,136,333
	2012	4,056,937	3,753,497	10,329,302	3,723,003	2,835,697	3,575,730	3,525,500	4,718,753	3,657,834	3,478,043	3,495,311	3,478,043	3,478,043
	2013	4,310,295	4,063,428	11,219,927	4,044,388	3,096,205	3,887,457	3,817,939	5,112,756	3,975,009	3,783,237	3,805,437	3,783,861	3,783,237
	2014	4,518,223	4,328,329	12,029,289	4,321,707	3,324,282	4,156,641	4,066,146	5,448,612	4,248,514	4,047,226	4,074,891	4,049,340	4,047,226
		3	4	1	5	13	7	9	2	6	11	8	10	11

	YEAR	O.1-4	A.19	A.13c	A.13a	A.7	A.6	A.3	A.2b	A.2a	A.1b	A.1a Alcohol Blending 10%	A.1a Alcohol Blending 7.5%	A.1a (5%)
L	1995	57,731	57,420	57,424	57,424	56,802	57,321	57,256	57,364	57,405	57,141	57,141	57,141	57,141
P	1996	81,415	79,324	340,861	79,337	69,566	77,794	76,808	78,406	79,050	75,020	75,020	75,020	75,020
G	1997	119,100	110,078	809,476	110,114	88,237	106,677	104,477	107,909	109,474	100,481	100,481	100,481	100,481
	1998	192,582	162,981	1,473,983	183,541	122,664	156,748	152,698	158,712	161,894	145,331	145,331	145,331	145,331
	1999	523,550	454,580	2,210,482	496,170	313,152	436,878	422,106	442,164	455,681	395,283	395,283	395,283	395,283
	2000	886,707	749,289	3,107,234	806,586	508,279	720,121	694,865	727,296	752,259	648,988	648,988	648,988	648,988
	2001	1,282,995	1,044,585	4,137,699	1,116,920	706,369	1,003,798	968,411	1,011,775	1,048,811	904,090	904,090	904,090	904,090
	2002	1,763,239	1,431,190	5,316,524	1,520,461	970,119	1,376,448	1,328,227	1,383,978	1,437,756	1,240,511	1,240,511	1,240,511	1,240,511
	2003	2,365,311	1,884,407	6,631,304	1,990,120	1,313,986	1,822,110	1,792,930	1,821,196	1,894,290	1,675,870	1,675,870	1,675,870	1,675,870
	2004	3,077,735	2,456,019	8,249,134	2,577,896	1,749,136	2,382,696	2,375,251	2,369,821	2,468,400	2,222,570	2,222,570	2,222,570	2,222,570
	2005	3,876,125	3,128,140	9,993,132	3,268,852	2,266,596	3,043,471	3,061,724	3,013,571	3,144,411	2,868,291	2,868,291	2,868,291	2,868,291
	2006	4,747,635	3,906,637	11,621,305	4,064,978	2,866,810	3,807,909	3,853,014	3,756,921	3,926,615	3,613,624	3,614,600	3,613,624	3,613,624
	2007	5,579,930	4,684,010	13,379,658	4,841,987	3,471,510	4,570,475	4,587,240	4,495,760	4,705,975	4,358,955	4,362,341	4,358,955	4,358,955
	2008	6,195,348	5,280,080	15,035,701	5,438,228	3,962,102	5,158,166	5,155,008	5,056,558	5,302,176	4,948,383	4,955,498	4,948,383	4,948,383
	2009	6,769,473	5,872,002	16,570,496	6,034,718	4,454,966	5,744,006	5,721,950	5,612,726	5,895,077	5,537,491	5,549,482	5,537,491	5,537,491
	2010	7,311,624	6,471,293	17,969,834	6,636,102	4,953,814	6,334,883	6,298,167	6,172,193	6,492,945	6,131,570	6,149,444	6,131,570	6,131,570
	2011	7,768,710	6,996,715	19,271,192	7,155,173	5,398,271	6,847,053	6,797,797	6,653,327	7,008,570	6,654,480	6,679,226	6,654,480	6,654,480
	2012	8,118,585	7,465,890	20,459,292	7,619,173	5,780,779	7,299,656	7,213,791	7,080,637	7,468,485	7,098,282	7,130,802	7,098,282	7,098,282
	2013	8,358,296	7,833,636	21,447,986	7,982,082	6,087,266	7,654,179	7,529,793	7,412,400	7,827,878	7,446,911	7,488,036	7,447,979	7,446,911
	2014	8,508,179	8,107,738	22,244,145	8,250,409	6,322,144	7,916,894	7,751,461	7,655,538	8,093,248	7,706,372	7,756,847	7,709,973	7,706,372
OHOL VE		2	4	1	3	13	6	8	12	5	10	7	9	10

	OHOL VEH	O.1-4	A.19	A.13c	A.13a	A.7	A.6	A.3	A.2b	A.2a	A.1b	A.1a Alcohol Blending 10%	A.1a Alcohol Blending 7.5%	A.1a (5%)
A	1995	15	15	15	15	15	15	15	15	15	15	15	15	15
L	1996	20	19	19	19	21	19	19	19	19	20	20	20	20
C	1997	68	63	655	63	91	68	70	61	64	75	75	75	75
O	1998	148	125	1,679	125	189	135	141	121	127	153	153	153	153
H	1999	299	225	3,115	263	347	243	255	216	228	278	278	278	278
O	2000	984	815	5,303	882	1,254	882	927	777	826	1,007	1,007	1,007	1,007
L	2001	1,788	1,432	7,833	1,520	2,211	1,553	1,631	1,364	1,455	1,773	1,773	1,773	1,773
	2002	2,731	2,078	10,809	2,187	3,217	2,255	2,368	1,977	2,111	2,575	2,575	2,575	2,575
V	2003	4,252	2,945	14,230	3,075	4,570	3,195	3,356	2,796	2,991	3,651	3,651	3,651	3,651
E	2004	6,106	4,271	18,131	4,432	6,367	4,582	4,667	4,059	4,335	5,078	5,078	5,078	5,078
H	2005	8,328	5,967	23,079	6,155	8,681	6,354	6,356	5,666	6,048	6,915	6,915	6,915	6,915
I	2006	10,771	7,969	28,422	8,185	11,417	8,445	8,342	7,558	8,071	9,079	9,079	9,079	9,079
C	2007	13,455	10,302	35,054	10,549	14,633	10,891	10,672	9,764	10,435	11,618	11,614	11,618	11,618
L	2008	16,070	12,705	41,937	12,945	17,946	13,404	13,345	12,026	12,864	14,224	14,207	14,224	14,224
E	2009	18,219	14,752	48,400	14,996	20,725	15,532	15,574	13,946	14,932	16,385	16,350	16,385	16,385
S	2010	20,284	16,848	54,576	17,102	23,574	17,708	17,857	15,905	17,048	18,596	18,534	18,596	18,596
	2011	22,275	18,974	60,475	19,264	26,499	19,942	20,186	17,912	19,219	20,863	20,768	20,863	20,863
	2012	23,842	20,984	66,240	21,278	29,179	22,012	22,344	19,780	21,240	22,936	22,802	22,936	22,936
	2013	25,101	22,667	71,798	22,965	31,563	23,773	24,287	21,336	22,936	24,775	24,595	24,775	24,775
	2014	26,048	24,077	76,881	24,382	33,570	25,251	25,963	22,636	24,360	26,318	26,088	26,311	26,318
	ECTRIC VEH	7	12	1	10	2	9	8	13	11	3	6	5	3

ECTRIC VEI		O.1-4	A.19	A.13c	A.13a	A.7	A.6	A.3	A.2b	A.2a	A.1b	A.1a Alcohol Blending 10%	A.1a Alcohol Blending 7.5%	A.1a (5%)
E	1995	20	20	20	20	19	20	20	20	20	20	20	20	20
L	1996	30	29	156	29	25	28	28	33	29	27	27	27	27
E	1997	48	42	404	42	33	40	40	51	42	38	38	38	38
C	1998	89	69	794	79	50	66	64	87	68	60	60	60	60
T	1999	292	253	1,277	260	159	228	219	319	238	204	204	204	204
R	2000	557	466	1,949	465	287	415	400	585	435	372	372	372	372
I	2001	890	698	2,780	694	432	625	602	879	655	560	560	560	560
C	2002	1,327	1,033	3,807	1,020	643	926	892	1,299	970	831	831	831	831
	2003	1,913	1,458	5,050	1,429	938	1,314	1,296	1,829	1,368	1,208	1,208	1,208	1,208
V	2004	2,672	2,041	6,738	2,002	1,359	1,861	1,862	2,566	1,928	1,739	1,739	1,739	1,739
E	2005	3,578	2,789	8,764	2,733	1,903	2,560	2,587	3,503	2,645	2,420	2,420	2,420	2,420
H	2006	4,616	3,715	10,838	3,634	2,579	3,425	3,480	4,656	3,530	3,260	3,261	3,260	3,260
I	2007	5,689	4,706	13,311	4,603	3,321	4,365	4,387	5,902	4,492	4,176	4,180	4,176	4,176
C	2008	6,677	5,650	15,898	5,534	4,056	5,271	5,266	7,083	5,415	5,069	5,078	5,069	5,069
L	2009	7,679	6,661	18,587	6,535	4,850	6,242	6,208	8,344	6,403	6,028	6,043	6,028	6,028
E	2010	8,705	7,761	21,373	7,614	5,712	7,291	7,231	9,698	7,470	7,064	7,088	7,064	7,064
S	2011	9,654	8,754	24,081	8,643	6,546	8,293	8,209	10,983	8,487	8,062	8,095	8,062	8,062
	2012	10,508	9,722	26,754	9,643	7,345	9,261	9,131	12,222	9,474	9,008	9,053	9,008	9,008
	2013	11,250	10,605	29,284	10,556	8,081	10,146	9,965	13,344	10,375	9,874	9,932	9,876	9,874
	2014	11,884	11,384	31,639	11,367	8,744	10,933	10,695	14,331	11,174	10,645	10,718	10,651	10,645
LPG VEHIC		3	4	1	5	13	7	9	2	6	11	8	10	11

LPG VEHIC		O.1-4	A.19	A.13c	A.13a	A.7	A.6	A.3	A.2b	A.2a	A.1b	A.1a Alcohol Blending 10%	A.1a Alcohol Blending 7.5%	A.1a (5%)
L	1995	127	126	126	126	125	126	126	126	126	126	126	126	126
P	1996	180	175	754	176	154	172	170	173	175	166	166	166	166
G	1997	266	246	1,807	246	197	238	233	241	244	224	224	224	224
	1998	434	367	3,320	413	276	353	344	357	365	327	327	327	327
V	1999	1,190	1,033	5,025	1,128	712	993	960	1,005	1,036	899	899	899	899
E	2000	2,044	1,727	7,162	1,859	1,172	1,660	1,602	1,676	1,734	1,496	1,496	1,496	1,496
H	2001	2,999	2,442	9,672	2,611	1,651	2,346	2,264	2,365	2,452	2,113	2,113	2,113	2,113
I	2002	4,181	3,393	12,606	3,605	2,300	3,264	3,149	3,281	3,409	2,941	2,941	2,941	2,941
C	2003	5,690	4,533	15,952	4,787	3,161	4,383	4,313	4,381	4,557	4,031	4,031	4,031	4,031
L	2004	7,513	5,995	20,137	6,293	4,270	5,816	5,798	5,785	6,026	5,426	5,426	5,426	5,426
E	2005	9,531	7,691	24,571	8,037	5,573	7,483	7,528	7,410	7,731	7,052	7,052	7,052	7,052
S	2006	11,759	9,676	28,783	10,068	7,100	9,431	9,543	9,305	9,725	8,950	8,952	8,950	8,950
	2007	13,921	11,686	33,381	12,080	8,661	11,403	11,445	11,217	11,741	10,875	10,884	10,875	10,875
	2008	15,571	13,271	37,790	13,668	9,958	12,964	12,956	12,709	13,326	12,437	12,455	12,437	12,437
	2009	17,141	14,869	41,959	15,281	11,281	14,545	14,489	14,212	14,927	14,022	14,052	14,022	14,022
	2010	18,653	16,509	45,844	16,930	12,638	16,161	16,068	15,746	16,564	15,643	15,688	15,643	15,643
	2011	19,969	17,985	49,536	18,392	13,876	17,600	17,473	17,102	18,015	17,105	17,169	17,105	17,105
	2012	21,028	19,337	52,991	19,734	14,973	18,907	18,684	18,339	19,344	18,385	18,469	18,385	18,385
	2013	21,815	20,446	55,979	20,833	15,888	19,977	19,653	19,346	20,431	19,436	19,544	19,439	19,436
	2014	22,378	21,325	58,507	21,700	16,628	20,823	20,388	20,136	21,287	20,269	20,402	20,279	20,269
		2	4	1	3	13	6	8	12	5	10	7	9	10

	YEAR	O.1-4	A.19	A.13c	A.13a	A.7	A.6	A.3	A.2b	A.2a	A.1b	A.1a Alcohol Blending 10%	A.1a Alcohol Blending 7.5%	A.1a (5%)
$	1995	($0.03)	($0.01)	($0.03)	($0.03)	$0.19	($0.00)	($0.00)	($0.02)	($0.03)	($0.00)	$0.58	$0.58	$0.58
	1996	($0.05)	($0.03)	$5.40	($0.04)	$0.51	($0.00)	($0.00)	($0.04)	($0.05)	($0.00)	$0.57	$0.58	$0.58
P	1997	($0.06)	($0.02)	$4.67	($0.06)	$0.69	($0.01)	($0.00)	($0.05)	($0.06)	($0.00)	$0.57	$0.58	$0.58
E	1998	($0.07)	($0.01)	$3.99	$0.57	$0.79	($0.01)	($0.00)	($0.06)	($0.06)	($0.00)	$0.57	$0.57	$0.57
R	1999	($0.07)	$0.48	$2.51	$0.14	$0.90	($0.01)	($0.01)	($0.07)	($0.07)	($0.01)	$0.56	$0.55	$0.55
	2000	($0.07)	$0.20	$2.20	$0.08	$0.92	($0.01)	($0.02)	($0.07)	($0.07)	($0.01)	$0.54	$0.54	$0.52
G	2001	($0.07)	$0.14	$1.95	$0.04	$0.66	($0.01)	($0.02)	($0.07)	($0.07)	($0.01)	$0.53	$0.52	$0.49
E	2002	($0.08)	$0.17	$1.66	$0.01	$0.66	($0.01)	($0.03)	($0.07)	($0.07)	($0.02)	$0.51	$0.50	$0.46
G	2003	($0.08)	$0.10	$1.42	($0.01)	$0.66	($0.01)	($0.03)	($0.07)	($0.07)	($0.02)	$0.49	$0.47	$0.43
	2004	($0.08)	$0.10	$1.28	($0.03)	$0.66	($0.01)	($0.04)	($0.07)	($0.08)	($0.03)	$0.46	$0.44	$0.39
D	2005	($0.08)	$0.10	$1.16	($0.04)	$0.66	($0.01)	($0.04)	($0.07)	($0.08)	($0.03)	$0.44	$0.41	$0.35
I	2006	($0.08)	$0.04	$0.96	($0.05)	$0.65	($0.01)	($0.04)	($0.07)	($0.08)	($0.03)	$0.41	$0.37	$0.31
S	2007	($0.08)	$0.03	$0.92	($0.05)	$0.65	($0.01)	($0.05)	($0.07)	($0.08)	($0.04)	$0.39	$0.35	$0.28
P	2008	($0.08)	$0.03	$0.83	($0.06)	$0.65	($0.01)	($0.05)	($0.07)	($0.08)	($0.04)	$0.37	$0.32	$0.26
L	2009	($0.08)	$0.02	$0.75	($0.06)	$0.64	($0.01)	($0.05)	($0.07)	($0.08)	($0.04)	$0.35	$0.31	$0.24
A	2010	($0.08)	($0.08)	$0.67	($0.06)	$0.64	($0.01)	($0.06)	($0.07)	($0.08)	($0.05)	$0.33	$0.29	$0.22
C	2011	($0.08)	($0.08)	$0.64	($0.06)	$0.46	($0.01)	($0.06)	($0.07)	($0.08)	($0.05)	$0.32	$0.27	$0.21
E	2012	($0.08)	($0.08)	$0.61	($0.06)	$0.46	($0.01)	($0.06)	($0.07)	($0.08)	($0.05)	$0.31	$0.26	$0.20
D	2013	($0.08)	($0.08)	$0.59	($0.06)	$0.45	($0.01)	($0.06)	($0.07)	($0.08)	($0.05)	$0.30	$0.26	$0.19
	2014	($0.08)	($0.08)	$0.58	($0.06)	$0.45	($0.01)	($0.06)	($0.07)	($0.08)	($0.05)	$0.30	$0.25	$0.18
		2	3	13	5	12	8	6	4	1	7	11	10	9

	YEAR	O.1-4	A.19	A.13c	A.13a	A.7	A.6	A.3	A.2b	A.2a	A.1b	A.1a Alcohol Blending 10%	A.1a Alcohol Blending 7.5%	A.1a (5%)
$	1995	($11)	($6)	($11)	($11)	$81	($2)	($11)	($11)	($11)	($11)	$86,572	$64,927	$43,281
	1996	($35)	($19)	$23,216	($33)	$377	($4)	($36)	($32)	($33)	($38)	$93,676	$70,247	$46,819
P	1997	($43)	($17)	$5,194	($39)	$478	($4)	($43)	($37)	($39)	($46)	$58,078	$43,547	$29,016
E	1998	($52)	($10)	$3,294	$460	$561	($4)	($49)	($42)	($44)	($53)	$37,864	$28,385	$18,905
R	1999	($94)	$666	$1,772	$188	$1,251	($8)	($109)	($92)	($98)	($117)	$23,757	$17,789	$11,820
	2000	($56)	$148	$1,394	$57	$689	($4)	($59)	($50)	($53)	($64)	$7,489	$5,600	$3,712
A	2001	($47)	$86	$1,146	$24	$407	($3)	($49)	($41)	($44)	($53)	$4,336	$3,238	$2,141
F	2002	($48)	$102	$924	$8	$395	($3)	($48)	($40)	($43)	($51)	$3,001	$2,238	$1,475
V	2003	($46)	$56	$752	($8)	$382	($3)	($46)	($40)	($43)	($50)	$2,112	$1,572	$1,031
	2004	($44)	$54	$671	($15)	$369	($3)	($44)	($40)	($43)	($48)	$1,509	$1,120	$731
	2005	($41)	$51	$583	($20)	$352	($3)	($42)	($39)	($41)	($46)	$1,104	$816	$529
	2006	($40)	$22	$471	($25)	$339	($3)	($41)	($38)	($40)	($44)	$834	$615	$395
	2007	($38)	$16	$438	($26)	$321	($3)	($40)	($36)	($38)	($42)	$647	$474	$302
	2008	($36)	$13	$380	($26)	$299	($3)	($37)	($33)	($36)	($39)	$525	$384	$243
	2009	($35)	$11	$334	($27)	$291	($2)	($36)	($33)	($35)	($38)	$453	$330	$207
	2010	($34)	($34)	$293	($27)	$284	($2)	($36)	($32)	($34)	($37)	$396	$288	$180
	2011	($33)	($33)	$271	($27)	$197	($2)	($35)	($31)	($33)	($36)	$351	$254	$158
	2012	($32)	($32)	$255	($26)	$191	($2)	($34)	($30)	($32)	($35)	$318	$230	$142
	2013	($31)	($31)	$241	($26)	$186	($2)	($33)	($29)	($32)	($34)	$294	$212	$130
	2014	($30)	($30)	$232	($25)	$181	($2)	($33)	($29)	($31)	($33)	$277	$199	$122
		5	4	12	7	10	8	2	6	3	1	13	11	9

	YEAR	O.1-4	A.19	A.13c	A.13a	A.7	A.6	A.3	A.2b	A.2a	A.1b	A.1a Alcohol Blending 10%	A.1a Alcohol Blending 7.5%	A.1a (5%)
N	1995	0	0	0	0	0	0	18	0	0	1,130	2,260	1,652	1,130
U	1996	0	0	0	0	0	0	18	0	0	1,130	2,260	1,652	1,130
M	1997	0	0	0	0	0	0	18	0	0	1,130	2,347	1,739	1,130
B	1998	0	0	4	0	0	0	22	0	0	1,130	2,347	1,739	1,130
E	1999	0	0	7	0	0	0	22	0	0	1,130	2,347	1,739	1,130
R	2000	0	0	11	0	0	0	26	0	0	1,217	2,434	1,826	1,217
	2001	4	0	15	0	4	0	26	0	0	1,217	2,434	1,826	1,217
O	2002	4	4	22	4	4	4	29	4	4	1,304	2,521	1,913	1,304
F	2003	7	4	26	4	7	4	29	4	4	1,304	2,521	1,913	1,304
	2004	11	7	33	7	11	7	33	7	7	1,391	2,608	2,000	1,391
J	2005	15	11	956	11	15	11	37	11	11	1,478	2,695	2,087	1,478
O	2006	18	15	1,217	15	18	15	956	11	15	1,565	2,782	2,174	1,565
B	2007	22	18	1,391	18	26	18	1,043	15	18	1,652	2,869	2,260	1,652
S	2008	26	18	1,652	18	29	22	1,130	18	18	1,739	2,956	2,347	1,739
	2009	29	22	1,826	22	33	22	1,217	22	22	1,826	3,043	2,434	1,826
	2010	29	26	2,000	26	37	26	1,304	26	26	1,913	3,130	2,521	1,913
	2011	33	29	2,174	29	956	29	1,391	26	29	2,000	3,217	2,608	2,000
	2012	33	29	2,347	29	1,043	33	1,478	29	29	2,000	3,304	2,695	2,000
	2013	33	33	2,521	33	1,043	33	1,565	29	33	2,087	3,391	2,782	2,087
	2014	37	33	2,608	33	1,130	37	1,652	33	33	2,174	3,478	2,782	2,174
		8	10	3	10	7	8	6	10	10	4	1	2	4

	YEAR	O.1-4	A.19	A.13c	A.13a	A.7	A.6	A.3	A.2b	A.2a	A.1b	A.1a Alcohol Blending 10%	A.1a Alcohol Blending 7.5%	A.1a (5%)
$	1995	($1,945)	($1,054)	($1,884)	($1,884)	$14,283	($319)	($105)	($1,871)	($1,889)	($2)	$6,755	$6,932	$6,754
	1996	($5,844)	($3,165)	$3,821,637	($5,434)	$62,392	($592)	($325)	($5,290)	($5,493)	($6)	$6,832	$7,011	$6,829
P	1997	($12,075)	($4,527)	$8,130,095	($10,310)	$128,894	($971)	($627)	($9,973)	($10,443)	($11)	$6,638	$6,720	$6,888
E	1998	($23,848)	($4,323)	$3,494,659	$190,167	$234,936	($1,590)	($922)	($17,394)	($18,311)	($19)	$6,696	$6,776	$6,944
R	1999	($77,017)	$439,943	$1,746,994	$141,828	$842,287	($5,173)	($3,270)	($61,028)	($64,790)	($69)	$6,733	$6,806	$6,957
	2000	($137,618)	$310,635	$1,470,449	$128,742	$1,464,811	($8,817)	($4,856)	($105,367)	($112,168)	($111)	$6,489	$6,471	$6,434
J	2001	($56,389)	$311,577	$1,323,479	$92,271	$407,344	($12,505)	($6,943)	($150,318)	($160,287)	($158)	$6,484	$6,458	$6,405
O	2002	($86,128)	$145,093	$977,263	$11,500	$570,536	($4,734)	($8,482)	($57,104)	($61,000)	($206)	$6,246	$6,140	$5,935
B	2003	($60,815)	$113,483	$898,110	($17,286)	$391,758	($6,548)	($11,618)	($81,382)	($86,803)	($283)	$6,219	$6,100	$5,870
	2004	($54,422)	$75,275	$795,325	($22,281)	$350,956	($4,411)	($13,851)	($55,837)	($59,535)	($356)	$5,969	$5,777	$5,418
	2005	($52,374)	$65,180	$30,470	($26,019)	$343,679	($3,842)	($16,238)	($49,208)	($52,495)	($436)	$5,767	$5,509	$5,040
	2006	($51,936)	$27,667	$23,901	($31,701)	$349,845	($3,663)	($790)	($63,035)	($50,477)	($523)	$5,565	$5,248	$4,685
	2007	($51,297)	$20,220	$23,498	($34,623)	$304,246	($3,561)	($898)	($57,752)	($49,375)	($602)	$5,370	$5,002	$4,362
	2008	($49,456)	$20,670	$20,395	($41,988)	$305,183	($3,394)	($959)	($53,133)	($56,842)	($654)	$5,199	$4,788	$4,091
	2009	($47,803)	$17,028	$18,676	($41,241)	$306,278	($3,823)	($1,013)	($50,086)	($53,639)	($701)	$5,041	$4,593	$3,849
	2010	($52,086)	($50,779)	$16,879	($40,806)	$307,544	($3,649)	($1,060)	($47,956)	($51,415)	($745)	$4,891	$4,411	$3,627
	2011	($49,184)	($48,739)	$15,944	($39,946)	$9,246	($3,484)	($1,091)	($52,525)	($49,315)	($778)	$4,754	$4,246	$3,433
	2012	($51,389)	($52,241)	$15,164	($43,364)	$9,098	($3,314)	($1,107)	($49,188)	($52,840)	($833)	$4,631	$4,100	$3,406
	2013	($52,919)	($48,942)	$14,512	($40,973)	$9,603	($3,488)	($1,108)	($51,777)	($49,494)	($842)	$4,524	$3,973	$3,251
	2014	($48,519)	($50,867)	$14,409	($42,821)	$9,224	($3,259)	($1,098)	($47,784)	($51,434)	($840)	$4,431	$3,985	$3,120
		3	2	13	5	12	6	7	4	1	8	11	10	9

	YEAR	O.1-4	A.19	A.13c	A.13a	A.7	A.6	A.3	A.2b	A.2a	A.1b	A.1a (10%)	A.1a (7.5%)	A.1a (5%)
#	1995	161	161	161	161	159	160	160	161	160	160	160	160	160
	1996	230	223	929	223	200	219	217	225	222	213	213	213	213
O	1997	382	351	2,866	351	320	346	343	354	350	337	337	337	337
F	1998	671	561	5,793	617	515	554	549	566	560	541	541	541	541
	1999	1,781	1,511	9,417	1,651	1,217	1,464	1,434	1,540	1,502	1,380	1,380	1,380	1,380
A	2000	3,585	3,007	14,414	3,206	2,712	2,958	2,928	3,038	2,996	2,874	2,874	2,874	2,874
F	2001	5,677	4,572	20,285	4,825	4,294	4,525	4,497	4,608	4,561	4,446	4,446	4,446	4,446
V	2002	8,238	6,504	27,222	6,812	6,160	6,445	6,410	6,557	6,490	6,347	6,347	6,347	6,347
	2003	11,855	8,935	35,232	9,292	8,669	8,893	8,966	9,006	8,916	8,890	8,890	8,890	8,890
	2004	16,291	12,308	45,006	12,727	11,995	12,259	12,328	12,410	12,289	12,242	12,242	12,242	12,242
	2005	21,436	16,448	56,414	16,925	16,158	16,398	16,471	16,579	16,425	16,388	16,388	16,388	16,388
	2006	27,146	21,360	68,043	21,886	21,096	21,301	21,365	21,519	21,327	21,290	21,293	21,290	21,290
	2007	33,066	26,694	81,746	27,233	26,615	26,660	26,504	26,883	26,668	26,670	26,677	26,670	26,670
	2008	38,319	31,627	95,625	32,147	31,960	31,639	31,567	31,819	31,605	31,730	31,740	31,730	31,730
	2009	43,039	36,282	108,945	36,811	36,856	36,318	36,271	36,502	36,262	36,435	36,445	36,435	36,435
	2010	47,642	41,118	121,793	41,646	41,923	41,160	41,155	41,350	41,082	41,303	41,310	41,303	41,303
	2011	51,899	45,713	134,092	46,299	46,921	45,835	45,868	45,997	45,721	46,030	46,032	46,030	46,030
	2012	55,378	50,043	145,984	50,655	51,497	50,180	50,159	50,341	50,057	50,329	50,324	50,329	50,329
	2013	58,166	53,718	157,061	54,354	55,532	53,896	53,904	54,026	53,742	54,085	54,071	54,089	54,085
	2014	60,310	56,787	167,027	57,449	58,942	57,006	57,046	57,103	56,821	57,232	57,208	57,240	57,232

#	YEAR	O.1-4	A.19	A.13c	A.13a	A.7	A.6	A.3	A.2b	A.2a	A.1b	A.1a Alcohol Blending 10%	A.1a Alcohol Blending 7.5%	A.1a (5%)
	1995	2	1	1	1	2	1	1	1	1	1	1	1	1
O	1996	7	2	594	2	4	2	3	2	2	3	3	3	3
F	1997	24	5	1,199	5	11	6	6	5	5	7	7	7	7
	1998	72	12	1,815	12	24	14	15	12	12	17	17	17	17
P	1999	564	443	2,756	442	682	480	504	421	449	547	547	547	547
R	2000	715	465	3,477	466	726	506	532	442	473	579	579	579	579
I	2001	933	507	4,235	506	800	551	579	480	515	632	632	632	632
V	2002	1,638	786	5,017	785	1,241	854	898	743	798	979	979	979	979
A	2003	2,174	1,247	5,826	1,252	1,735	1,311	1,252	1,189	1,265	1,366	1,366	1,366	1,366
T	2004	2,653	1,645	7,178	1,645	2,286	1,723	1,645	1,559	1,662	1,796	1,796	1,796	1,796
E	2005	3,054	2,069	8,551	2,070	2,892	2,169	2,070	1,958	2,092	2,262	2,262	2,262	2,262
	2006	3,414	2,524	10,788	2,532	3,551	2,655	2,532	2,391	2,559	2,769	2,765	2,769	2,769
A	2007	3,486	2,752	12,380	2,753	3,888	2,888	3,015	2,596	2,782	3,015	3,003	3,015	3,015
L	2008	3,543	2,971	13,300	2,972	4,223	3,120	3,260	2,798	3,005	3,260	3,240	3,260	3,260
C	2009	3,594	3,175	14,224	3,177	4,533	3,337	3,487	2,986	3,212	3,487	3,458	3,487	3,487
O	2010	3,643	3,332	15,145	3,356	4,804	3,526	3,687	3,149	3,394	3,687	3,648	3,687	3,687
H	2011	3,716	3,530	16,178	3,530	5,054	3,709	3,878	3,311	3,570	3,878	3,830	3,878	3,878
O	2012	3,790	3,677	17,225	3,677	5,263	3,863	4,038	3,449	3,718	4,038	3,981	4,038	4,038
L	2013	3,865	3,801	18,286	3,801	5,434	3,993	4,173	3,564	3,843	4,173	4,107	4,166	4,173
	2014	3,941	3,907	19,366	3,907	5,577	4,103	4,287	3,662	3,950	4,287	4,213	4,270	4,287

	YEAR	O.1-4	A.19	A.13c	A.13a	A.7	A.6	A.3	A.2b	A.2a	A.1b	A.1a Alcohol Blending 10%	A.1a Alcohol Blending 7.5%	A.1a (5%)
O	1995	0	0	0	0	0	0	0	0	0	0	0	0	0
F	1996	2	1	128	1	0	0	0	1	1	0	0	0	0
	1997	6	1	285	1	1	1	1	2	1	1	1	1	1
P	1998	20	4	478	3	3	3	3	5	3	3	3	3	3
R	1999	167	141	637	129	82	121	117	174	128	108	108	108	108
I	2000	234	164	886	150	97	142	136	200	148	127	127	127	127
V	2001	326	185	1,150	173	115	164	158	230	172	148	148	148	148
A	2002	486	304	1,452	285	192	271	262	376	283	245	245	245	245
T	2003	684	415	1,797	389	289	376	389	512	386	364	364	364	364
E	2004	887	568	2,359	544	410	527	544	712	540	512	512	512	512
	2005	1,093	766	3,018	735	559	713	735	957	730	692	692	692	692
E	2006	1,279	985	3,450	944	723	916	944	1,223	938	891	892	891	891
L	2007	1,370	1,109	4,164	1,078	835	1,047	1,020	1,392	1,071	1,020	1,022	1,020	1,020
E	2008	1,461	1,257	4,707	1,222	957	1,189	1,159	1,573	1,215	1,159	1,163	1,159	1,159
C	2009	1,555	1,412	5,298	1,372	1,083	1,336	1,304	1,759	1,364	1,304	1,310	1,304	1,304
T	2010	1,655	1,572	5,939	1,523	1,211	1,485	1,449	1,945	1,515	1,449	1,458	1,449	1,449
R	2011	1,713	1,625	6,449	1,625	1,298	1,586	1,549	2,071	1,617	1,548	1,559	1,548	1,548
I	2012	1,773	1,719	6,982	1,719	1,378	1,677	1,639	2,184	1,710	1,639	1,651	1,639	1,639
C	2013	1,835	1,804	7,541	1,804	1,451	1,761	1,721	2,287	1,795	1,721	1,736	1,723	1,721
	2014	1,901	1,884	8,129	1,884	1,520	1,840	1,799	2,382	1,874	1,799	1,815	1,802	1,799

	YEAR	O.1-4	A.19	A.13c	A.13a	A.7	A.6	A.3	A.2b	A.2a	A.1b	A.1a (10%)	A.1a (7.5%)	A.1a (5%)
T	1995	(1,779)	(960)	(1,715)	(1,715)	12,863	(290)	(1,751)	(1,705)	(1,719)	(1,776)	13,831,915	10,373,492	6,915,069
O	1996	(8,071)	(4,289)	21,565,887	(7,362)	75,429	(789)	(7,841)	(7,221)	(7,418)	(8,159)	19,927,589	14,943,652	9,959,715
T	1997	(16,561)	(5,941)	14,884,522	(13,528)	153,223	(1,256)	(14,709)	(13,182)	(13,666)	(15,508)	19,600,001	14,696,124	9,792,247
A	1998	(34,670)	(5,873)	19,084,988	284,269	289,136	(2,128)	(26,904)	(23,819)	(24,808)	(28,516)	20,469,479	15,344,980	10,220,481
L	1999	(166,979)	1,005,951	16,689,740	309,931	1,523,437	(11,441)	(155,625)	(142,223)	(147,323)	(161,195)	32,795,192	24,556,095	16,316,999
	2000	(200,027)	444,657	20,090,495	181,884	1,870,035	(12,400)	(173,340)	(152,349)	(159,961)	(183,458)	21,524,825	16,097,754	10,670,684
C	2001	(267,433)	393,013	23,239,867	115,805	1,748,210	(15,593)	(220,596)	(191,067)	(201,743)	(235,227)	19,276,724	14,398,736	9,520,749
O	2002	(393,070)	663,213	25,160,962	52,305	2,431,537	(21,406)	(304,720)	(262,982)	(278,231)	(325,385)	19,046,270	14,203,356	9,360,442
S	2003	(541,771)	504,475	26,504,282	(76,488)	3,314,873	(28,911)	(413,011)	(364,388)	(385,091)	(441,528)	18,778,355	13,973,385	9,168,414
T	2004	(711,417)	662,112	30,185,058	(195,299)	4,425,164	(38,583)	(548,347)	(494,861)	(522,962)	(586,834)	18,473,636	13,708,518	8,943,401
S	2005	(889,476)	842,136	32,908,562	(335,258)	5,691,627	(49,388)	(699,677)	(640,237)	(677,371)	(750,063)	18,089,895	13,379,906	8,669,916
	2006	(1,082,412)	469,790	32,053,933	(536,852)	7,161,687	(61,900)	(874,985)	(807,824)	(855,895)	(939,209)	17,769,140	13,089,608	8,413,336
	2007	(1,250,985)	417,679	35,782,124	(712,808)	8,548,685	(73,298)	(1,047,874)	(959,802)	(1,019,002)	(1,112,941)	17,251,059	12,654,772	8,065,535
	2008	(1,363,216)	411,889	36,349,575	(835,256)	9,560,076	(80,993)	(1,172,824)	(1,063,479)	(1,131,946)	(1,232,144)	16,663,626	12,182,052	7,710,654
	2009	(1,491,360)	403,641	36,389,159	(976,640)	10,723,121	(90,467)	(1,322,850)	(1,192,161)	(1,270,823)	(1,376,410)	16,499,154	12,020,237	7,554,688
	2010	(1,613,840)	(1,396,426)	35,708,486	(1,120,798)	11,906,904	(100,134)	(1,475,270)	(1,323,336)	(1,412,651)	(1,523,462)	16,370,844	11,884,827	7,415,397
	2011	(1,697,184)	(1,511,313)	36,391,498	(1,238,413)	9,251,163	(107,947)	(1,600,510)	(1,430,269)	(1,529,120)	(1,642,828)	16,166,117	11,699,013	7,251,733
	2012	(1,756,490)	(1,606,947)	37,156,477	(1,333,670)	9,855,082	(114,565)	(1,708,486)	(1,517,496)	(1,625,156)	(1,743,840)	16,020,109	11,561,628	7,126,472
	2013	(1,793,513)	(1,677,300)	37,920,713	(1,404,078)	10,326,333	(119,446)	(1,794,453)	(1,581,114)	(1,698,028)	(1,821,294)	15,914,198	11,461,418	7,032,908
	2014	(1,815,089)	(1,729,128)	38,712,864	(1,455,637)	10,679,438	(123,010)	(1,861,763)	(1,627,525)	(1,748,299)	(1,878,571)	15,864,043	11,408,706	6,977,163

RESULTS OF EVALUATIONS OF GROUPS OF MEASURES

(APPENDIX A-4 cont'd)

		Common Element:	Ethanol Blending (	Ethanol Blending (	Alcohol (M85/E85)	Alcohol (M85/E85):	tric Vehicle Purch	) & Vehicle Incentive	ites & Fuel & Vehic	Everything	Future No Action
E N A I N I	YEAR	A. Common Elements Only	B. Ethanol Blending (10%)	C. Ethanol Blending (10%) & Alcohol Vehicle Incentives	D. Alcohol (M85/E85) Fuel & Vehicle Purchase Incentives	E. Alcohol (M85/E85) Fuel & Vehicle Purchase Incentives & Alcohol (10%) Blending	F. Alcohol & Electric Vehicle Purchase Incentives	G. Ethanol Blending (10%) & Vehicle Incentives; Fleet Mandates Later	H. Fleet Mandates & Fuel & Vehicle Incentives	I. Everything	Future No Action
N	1995	410,980,128	384,539,211	384,539,195	410,979,636	384,538,971	410,980,107	384,539,191	410,979,634	379,020,949	410,980,961
G	1996	416,433,816	389,681,055	389,680,976	416,431,421	389,679,885	416,433,712	389,514,232	415,837,607	383,425,485	416,439,406
	1997	420,932,886	393,928,542	393,928,251	420,924,087	393,924,246	420,932,490	393,424,720	419,342,709	386,581,013	420,957,021
G	1998	425,321,237	398,068,222	398,067,339	425,294,775	398,055,303	425,320,005	397,057,659	422,338,999	389,266,166	425,444,043
A	1999	429,152,741	401,681,174	401,679,227	429,094,474	401,652,723	429,149,913	400,412,260	424,849,813	391,502,598	429,410,161
S	2000	430,890,257	403,322,659	403,319,419	430,774,421	403,266,480	430,884,947	401,261,014	424,921,471	391,490,412	431,364,234
O	2001	432,422,843	404,757,897	404,752,322	432,216,805	404,658,143	432,414,082	401,552,707	424,418,056	390,947,908	433,224,746
L	2002	433,504,161	405,790,854	405,782,194	433,214,595	405,633,793	433,490,586	401,332,609	423,303,190	389,841,867	434,778,793
I	2003	434,168,994	406,417,051	406,406,885	433,770,552	406,195,889	434,151,646	400,619,473	421,587,374	388,182,422	435,952,138
N	2004	434,410,435	406,645,155	406,632,464	433,896,830	406,355,685	434,389,719	399,219,649	418,813,360	385,549,123	436,701,020
E	2005	437,697,146	409,725,456	409,710,168	437,064,524	409,364,162	437,672,111	400,411,910	418,804,208	385,461,435	440,455,724
	2006	440,782,817	412,622,427	412,606,281	440,036,859	412,190,250	440,755,105	401,198,940	418,410,846	385,020,213	443,920,257
&	2007	443,977,409	415,624,490	415,606,888	443,124,314	415,124,753	443,947,713	401,658,430	417,719,946	384,305,553	447,354,430
	2008	447,631,836	419,063,166	419,044,270	446,680,582	418,499,082	447,599,817	402,256,134	417,332,129	383,870,212	451,161,071
D	2009	451,375,919	422,593,121	422,573,193	450,341,006	421,971,688	451,342,083	403,080,687	417,241,202	383,708,497	454,953,249
I	2010	455,204,490	426,213,875	426,197,274	454,112,629	425,549,198	455,173,128	404,166,841	417,480,839	383,851,311	458,713,490
E	2011	459,345,723	430,124,502	430,109,674	458,200,228	429,423,562	459,318,784	405,491,927	418,019,894	384,269,831	462,662,768
S	2012	463,788,040	434,323,778	434,310,483	462,603,179	433,594,286	463,763,990	407,054,735	418,859,661	384,964,983	466,835,679
E	2013	468,541,818	438,819,866	438,808,379	467,327,848	438,067,427	468,520,630	409,017,467	420,194,667	386,115,256	471,279,713
L	2014	473,562,198	443,567,840	443,558,320	472,324,934	442,796,861	473,544,198	411,344,352	421,989,557	387,687,763	475,992,850
		9	6	5	7	4	8	2	3	1	

	YEAR	A. Common Elements Only	B. Ethanol Blending (10%)	C. Ethanol Blending (10%) & Alcohol Vehicle Incentives	D. Alcohol (M85/E85) Fuel & Vehicle Purchase Incentives	E. Alcohol (M85/E85) Fuel & Vehicle Purchase Incentives & Alcohol (10%) Blending	F. Alcohol & Electric Vehicle Purchase Incentives	G. Ethanol Blending (10%) & Vehicle Incentives; Fleet Mandates Later	H. Fleet Mandates & Fuel & Vehicle Incentives	I. Everything	Future No Action
A	1995	9,051	26,450,354	26,450,376	10,250	26,450,915	9,061	26,450,366	10,239	31,968,726	8,539
L	1996	32,708	26,790,847	26,790,950	44,992	26,796,527	32,754	26,876,256	427,429	32,815,700	28,598
C	1997	70,675	27,087,560	27,087,941	102,700	27,102,540	70,832	27,341,040	1,097,045	33,796,580	56,119
O	1998	160,666	27,442,471	27,443,630	240,764	27,480,236	161,100	27,941,769	2,057,134	35,012,589	99,672
H	1999	492,420	28,059,361	28,065,020	730,176	28,171,927	492,811	28,676,077	3,291,499	36,450,920	357,918
O	2000	865,004	28,596,701	28,606,343	1,290,334	28,798,275	863,817	29,596,551	4,746,768	37,908,391	621,288
L	2001	1,290,756	29,191,002	29,205,950	1,942,045	29,500,708	1,289,950	30,726,837	6,467,990	39,573,736	888,964
	2002	1,927,552	29,921,987	29,944,161	2,792,154	30,372,955	1,926,613	32,023,788	8,438,641	41,428,583	1,241,749
	2003	2,689,205	30,784,973	30,811,840	3,827,147	31,401,810	2,683,218	33,454,959	10,658,634	43,473,787	1,777,272
	2004	3,577,099	31,760,878	31,794,593	5,025,895	32,567,040	3,571,204	35,119,554	13,350,661	45,884,345	2,446,453
	2005	4,558,591	33,033,025	33,074,470	6,349,400	34,049,761	4,550,802	37,133,060	16,279,611	48,741,414	3,243,533
	2006	5,617,884	34,368,317	34,414,176	7,764,263	35,610,871	5,603,811	39,298,401	19,334,439	51,690,689	4,165,015
	2007	6,615,994	35,635,985	35,687,019	9,093,700	37,093,260	6,600,852	41,519,478	22,462,369	54,689,218	5,098,312
	2008	7,405,499	36,675,025	36,728,400	10,124,506	38,306,006	7,388,400	43,630,857	25,325,568	57,464,844	5,876,473
	2009	8,149,485	37,660,016	37,716,086	11,084,685	39,454,004	8,131,250	45,536,294	27,940,370	60,031,716	6,660,889
	2010	8,847,191	38,588,496	38,636,796	11,958,599	40,522,030	8,816,920	47,312,632	30,280,799	62,367,759	7,454,620
	2011	9,378,815	39,382,899	39,424,734	12,653,645	41,430,311	9,352,410	48,940,661	32,431,236	64,548,610	8,178,159
	2012	9,781,382	40,046,664	40,082,708	13,173,924	42,182,817	9,758,555	50,444,252	34,373,007	66,557,024	8,764,388
	2013	10,057,149	40,583,865	40,613,487	13,523,754	42,784,174	10,036,110	51,737,476	36,018,165	68,325,959	9,237,269
	2014	10,232,654	41,025,484	41,047,791	13,737,591	43,265,664	10,213,352	52,871,288	37,375,745	69,861,696	9,601,229
		8	5	4	7	3	9	2	6	1	

	YEAR	A. Common Elements Only	B. Ethanol Blending (10%)	C. Ethanol Blending (10%) & Alcohol Vehicle Incentives	D. Alcohol (M85/E85) Fuel & Vehicle Purchase Incentives	E. Alcohol (M85/E85) Fuel & Vehicle Purchase Incentives & Alcohol (10%) Blending	F. Alcohol & Electric Vehicle Purchase Incentives	G. Ethanol Blending (10%) & Vehicle Incentives; Fleet Mandates Later	H. Fleet Mandates & Fuel & Vehicle Incentives	I. Everything	Future No Action
E	1995	9,153	9,054	9,053	8,972	8,972	9,172	9,071	8,989	8,968	8,947
L	1996	15,051	13,921	13,914	12,977	12,977	15,153	32,186	64,228	61,066	12,996
E	1997	25,363	22,580	22,553	20,206	20,206	25,768	80,863	164,867	155,939	18,808
C	1998	54,547	47,628	47,538	41,626	41,626	55,880	171,366	329,184	310,910	30,425
T	1999	171,941	146,578	145,514	124,196	124,196	180,932	312,099	558,139	526,977	105,932
R	2000	318,352	272,086	270,179	231,012	231,012	337,500	571,130	866,445	818,326	190,866
I	2001	497,252	427,602	424,681	365,149	365,149	524,805	927,003	1,238,396	1,170,168	283,093
C	2002	731,106	645,300	640,910	553,609	553,609	770,970	1,377,138	1,703,615	1,610,753	413,156
	2003	1,036,314	927,430	921,857	798,762	798,762	1,093,550	1,929,843	2,249,033	2,127,689	574,052
	2004	1,418,543	1,281,153	1,273,917	1,106,817	1,106,817	1,486,264	2,604,655	2,976,021	2,817,641	796,889
	2005	1,876,323	1,704,911	1,695,620	1,475,381	1,475,381	1,959,830	3,451,138	3,807,238	3,606,776	1,084,626
	2006	2,391,728	2,183,795	2,173,017	1,890,864	1,890,864	2,493,805	4,384,849	4,754,686	4,507,038	1,436,711
	2007	2,910,511	2,667,698	2,655,278	2,311,081	2,311,081	3,022,130	5,459,094	5,805,457	5,506,319	1,814,297
	2008	3,377,986	3,111,896	3,098,521	2,699,719	2,699,719	3,496,432	6,528,260	6,867,062	6,517,173	2,169,980
	2009	3,844,200	3,556,760	3,542,242	3,088,829	3,088,829	3,968,225	7,627,306	7,930,293	7,530,848	2,546,387
	2010	4,311,983	4,004,714	3,991,692	3,483,137	3,483,137	4,445,781	8,647,014	9,001,710	8,553,569	2,947,737
	2011	4,730,838	4,401,284	4,389,747	3,832,254	3,832,254	4,846,177	9,632,204	10,004,142	9,511,019	3,323,239
	2012	5,094,606	4,748,023	4,737,887	4,137,694	4,137,694	5,193,895	10,567,243	10,965,833	10,430,420	3,681,073
	2013	5,397,947	5,040,001	5,031,430	4,395,428	4,395,428	5,483,660	11,436,120	11,845,249	11,272,530	3,999,784
	2014	5,643,742	5,278,837	5,272,179	4,608,253	4,608,253	5,714,669	12,217,608	12,662,997	12,057,054	4,274,506
		5	6	7	8	8	4	2	1	3	

	YEAR	A. Common Elements Only	B. Ethanol Blending (10%)	C. Ethanol Blending (10%) & Alcohol Vehicle Incentives	D. Alcohol (M85/E85) Fuel & Vehicle Purchase Incentives	E. Alcohol (M85/E85) Fuel & Vehicle Purchase Incentives & Alcohol (10%) Blending	F. Alcohol & Electric Vehicle Purchase Incentives	G. Ethanol Blending (10%) & Vehicle Incentives; Fleet Mandates Later	H. Fleet Mandates & Fuel & Vehicle Incentives	I. Everything	Future No Action
L	1995	57,540	57,252	57,248	57,014	57,014	57,531	57,244	57,010	57,229	57,424
P	1996	78,651	74,381	74,362	70,790	70,790	78,606	134,008	219,184	246,198	79,337
G	1997	112,552	102,688	102,618	94,262	94,262	112,376	280,622	493,770	564,855	110,114
	1998	197,753	175,528	175,315	156,297	156,297	197,184	527,729	907,279	1,042,920	163,070
	1999	508,829	437,917	435,201	375,200	375,200	502,185	862,809	1,440,799	1,659,727	459,985
	2000	845,072	725,245	720,617	618,770	618,770	832,227	1,383,560	2,082,964	2,400,454	759,614
	2001	1,212,147	1,042,566	1,035,864	890,837	890,837	1,193,796	2,041,911	2,843,588	3,276,086	1,059,110
	2002	1,665,029	1,463,425	1,453,871	1,253,725	1,253,725	1,639,052	2,825,778	3,732,357	4,296,357	1,451,780
	2003	2,228,455	1,984,119	1,972,353	1,705,069	1,705,069	2,193,594	3,728,505	4,738,669	5,449,404	1,911,534
	2004	2,891,941	2,597,532	2,582,847	2,237,203	2,237,203	2,849,475	4,808,982	5,973,550	6,861,853	2,489,593
	2005	3,632,452	3,283,040	3,264,960	2,831,663	2,831,663	3,579,928	6,025,838	7,324,331	8,404,839	3,170,083
	2006	4,436,920	4,031,237	4,010,759	3,479,398	3,479,398	4,374,253	7,363,440	8,749,528	10,030,283	3,957,425
	2007	5,189,863	4,735,891	4,712,973	4,090,289	4,090,289	5,120,138	8,779,420	10,221,901	11,706,895	4,741,685
	2008	5,750,631	5,279,471	5,256,078	4,568,506	4,568,506	5,677,748	10,121,464	11,576,792	13,247,168	5,340,777
	2009	6,277,026	5,793,267	5,768,951	5,019,713	5,019,713	6,200,876	11,366,457	12,818,741	14,656,884	5,936,294
	2010	6,772,780	6,278,658	6,256,961	5,448,952	5,448,952	6,695,831	12,516,939	13,939,581	15,927,087	6,536,746
	2011	7,185,125	6,673,643	6,654,862	5,799,618	5,799,618	7,117,848	13,574,361	14,968,662	17,090,713	7,054,131
	2012	7,499,590	6,979,388	6,963,208	6,071,829	6,071,829	7,441,461	14,536,010	15,900,513	18,142,256	7,516,103
	2013	7,713,840	7,193,634	7,180,288	6,264,101	6,264,101	7,664,262	15,349,306	16,679,266	19,018,700	7,876,862
	2014	7,847,320	7,332,735	7,322,653	6,392,607	6,392,607	7,807,296	16,027,144	17,319,034	19,735,345	8,142,973
		4	6	7	8	8	5	3	2	1	

	YEAR	A. Common Elements Only	B. Ethanol Blending (10%)	C. Ethanol Blending (10%) & Alcohol Vehicle Incentives	D. Alcohol (M85/E85) Fuel & Vehicle Purchase Incentives	E. Alcohol (M85/E85) Fuel & Vehicle Purchase Incentives & Alcohol (10%) Blending	F. Alcohol & Electric Vehicle Purchase Incentives	G. Ethanol Blending (10%) & Vehicle Incentives; Fleet Mandates Later	H. Fleet Mandates & Fuel & Vehicle Incentives	I. Everything	Future No Action
A	1995	15	15	15	15	15	15	15	15	15	15
L	1996	20	21	21	23	23	20	21	23	22	19
C	1997	72	87	87	100	100	72	301	946	893	63
O	1998	158	195	196	229	229	158	838	2,449	2,310	125
H	1999	362	455	458	542	542	363	1,736	4,634	4,370	225
O	2000	1,119	1,400	1,413	1,660	1,660	1,120	2,999	7,482	7,057	814
L	2001	1,994	2,501	2,523	2,974	2,974	1,991	5,129	10,941	10,324	1,432
	2002	3,017	3,800	3,836	4,540	4,540	3,015	7,900	15,119	14,275	2,078
V	2003	4,570	5,526	5,580	6,620	6,620	4,568	11,228	20,008	18,904	2,944
E	2004	6,469	7,687	7,753	9,206	9,206	6,455	15,056	25,640	24,242	4,275
H	2005	8,732	10,253	10,337	12,269	12,269	8,718	19,680	32,590	30,835	5,972
I	2006	11,209	13,052	13,156	15,612	15,612	11,189	24,682	40,028	37,899	7,975
C	2007	13,914	16,080	16,196	19,230	19,230	13,879	30,202	47,886	45,369	10,316
L	2008	16,506	18,968	19,098	22,688	22,688	16,469	35,997	56,042	53,132	12,720
E	2009	18,613	21,252	21,389	25,447	25,447	18,570	41,579	63,653	60,389	14,770
S	2010	20,636	23,419	23,565	28,068	28,068	20,589	46,685	70,748	67,166	16,866
	2011	22,571	25,462	25,588	30,508	30,508	22,493	51,493	77,251	73,388	19,018
	2012	24,108	27,142	27,252	32,526	32,526	24,040	55,953	83,363	79,242	21,022
	2013	25,334	28,462	28,558	34,121	34,121	25,275	60,118	89,029	84,676	22,700
	2014	26,249	29,423	29,502	35,297	35,297	26,194	63,729	94,007	89,463	24,109
		8	7	6	4	4	9	3	1	2	

SCEN_A-I XLS, Sheet5, 8/1/95, 11:40 AM

	YEAR	A. Common Elements Only	B. Ethanol Blending (10%)	C. Ethanol Blending (10%) & Alcohol Vehicle Incentives	D. Alcohol (M85/E85) Fuel & Vehicle Purchase Incentives	E. Alcohol (M85/E85) Fuel & Vehicle Purchase Incentives & Alcohol (10%) Blending	F. Alcohol & Electric Vehicle Purchase Incentives	G. Ethanol Blending (10%) & Vehicle Incentives; Fleet Mandates Later	H. Fleet Mandates & Fuel & Vehicle Incentives	I. Everything	Future No Action
E	1995	20	20	20	20	20	20	20	20	20	20
L	1996	33	31	31	29	29	34	71	142	135	29
E	1997	57	50	50	45	45	58	180	368	348	42
C	1998	123	107	107	94	94	126	386	741	700	69
T	1999	391	333	331	282	282	411	709	1,269	1,198	241
R	2000	734	627	623	532	532	778	1,316	1,997	1,886	440
I	2001	1,162	1,000	993	854	854	1,227	2,167	2,895	2,735	662
C	2002	1,733	1,530	1,520	1,313	1,313	1,828	3,265	4,039	3,819	980
	2003	2,493	2,231	2,218	1,921	1,921	2,631	4,642	5,410	5,118	1,381
V	2004	3,463	3,127	3,110	2,702	2,702	3,628	6,358	7,265	6,878	1,945
E	2005	4,613	4,192	4,169	3,628	3,628	4,819	8,486	9,361	8,868	2,667
H	2006	5,924	5,409	5,382	4,683	4,683	6,176	10,860	11,776	11,163	3,558
I	2007	7,261	6,656	6,625	5,766	5,766	7,540	13,620	14,484	13,738	4,527
C	2008	8,490	7,821	7,788	6,785	6,785	8,788	16,408	17,260	16,380	5,454
L	2009	9,734	9,006	8,969	7,821	7,821	10,048	19,313	20,080	19,069	6,448
E	2010	11,001	10,217	10,183	8,886	8,886	11,342	22,060	22,965	21,821	7,520
S	2011	12,160	11,313	11,284	9,851	9,851	12,457	24,759	25,715	24,448	8,542
	2012	13,195	12,298	12,271	10,717	10,717	13,453	27,370	28,402	27,016	9,534
	2013	14,089	13,154	13,132	11,472	11,472	14,312	29,848	30,916	29,421	10,439
	2014	14,844	13,884	13,867	12,121	12,121	15,031	32,135	33,306	31,712	11,243
		5	6	7	8	8	4	2	1	3	

	YEAR	A. Common Elements Only	B. Ethanol Blending (10%)	C. Ethanol Blending (10%) & Alcohol Vehicle Incentives	D. Alcohol (M85/E85) Fuel & Vehicle Purchase Incentives	E. Alcohol (M85/E85) Fuel & Vehicle Purchase Incentives & Alcohol (10%) Blending	F. Alcohol & Electric Vehicle Purchase Incentives	G. Ethanol Blending (10%) & Vehicle Incentives; Fleet Mandates Later	H. Fleet Mandates & Fuel & Vehicle Incentives	I. Everything	Future No Action
L	1995	126	126	126	125	125	126	126	125	126	126
P	1996	174	165	164	157	157	174	296	485	545	176
G	1997	251	229	229	210	210	251	626	1,102	1,261	246
	1998	445	395	395	352	352	444	1,189	2,044	2,349	367
V	1999	1,157	995	989	853	853	1,142	1,961	3,275	3,773	1,046
E	2000	1,948	1,672	1,661	1,426	1,426	1,918	3,189	4,801	5,533	1,751
H	2001	2,833	2,437	2,421	2,082	2,082	2,791	4,773	6,647	7,658	2,476
I	2002	3,948	3,470	3,447	2,973	2,973	3,886	6,700	8,850	10,187	3,442
C	2003	5,361	4,773	4,745	4,102	4,102	5,277	8,969	11,399	13,109	4,598
L	2004	7,060	6,341	6,305	5,461	5,461	6,956	11,739	14,582	16,750	6,077
E	2005	8,931	8,072	8,028	6,962	6,962	8,802	14,816	18,009	20,666	7,795
S	2006	10,989	9,984	9,933	8,617	8,617	10,834	18,237	21,670	24,842	9,801
	2007	12,948	11,816	11,758	10,205	10,205	12,774	21,904	25,503	29,208	11,830
	2008	14,454	13,269	13,211	11,482	11,482	14,270	25,439	29,097	33,295	13,423
	2009	15,894	14,669	14,608	12,711	12,711	15,701	28,781	32,459	37,113	15,031
	2010	17,278	16,018	15,962	13,901	13,901	17,082	31,933	35,562	40,632	16,676
	2011	18,469	17,154	17,106	14,908	14,908	18,296	34,892	38,476	43,931	18,132
	2012	19,424	18,077	18,035	15,726	15,726	19,274	37,649	41,183	46,990	19,467
	2013	20,133	18,775	18,740	16,349	16,349	20,004	40,061	43,533	49,638	20,558
	2014	20,640	19,287	19,260	16,814	16,814	20,535	42,155	45,552	51,908	21,418
		4	6	7	8	8	5	3	2	1	

	YEAR	A	B	C	D	E	F	G	H	I	Future No Action
$	1995	($0.00)	$0.58	$0.58	$0.20	$1.20	$0.02	$0.58	$0.21	$0.90	($0.03)
	1996	($0.00)	$0.57	$0.57	$0.53	$1.20	$0.06	$0.61	$5.15	$0.99	($0.04)
P	1997	($0.01)	$0.57	$0.57	$0.76	$1.20	$0.15	$0.65	$4.27	$1.07	($0.06)
E	1998	$0.58	$0.58	$0.58	$1.25	$1.20	$0.82	$0.69	$3.47	$1.13	($0.06)
R	1999	$0.18	$0.56	$0.57	$1.28	$1.19	$0.83	$0.64	$2.66	$1.13	($0.07)
	2000	$0.11	$0.54	$0.56	$0.91	$1.17	$0.49	$0.73	$2.25	$1.14	($0.07)
G	2001	$0.08	$0.53	$0.54	$0.87	$1.15	$0.43	$0.81	$2.04	$1.16	($0.07)
E	2002	$0.05	$0.50	$0.53	$0.86	$1.12	$0.42	$0.85	$1.73	$1.12	($0.07)
G	2003	$0.04	$0.48	$0.50	$0.78	$1.09	$0.29	$0.82	$1.56	$1.11	($0.07)
	2004	$0.03	$0.45	$0.48	$0.76	$1.06	$0.26	$0.84	$1.07	$1.05	($0.08)
D	2005	$0.02	$0.43	$0.45	$0.74	$1.03	$0.24	$0.79	$1.04	$1.06	($0.08)
I	2006	$0.01	$0.40	$0.42	$0.70	$0.99	$0.16	$0.81	$1.01	$1.06	($0.08)
S	2007	$0.01	$0.38	$0.40	$0.68	$0.97	$0.14	$0.78	$1.00	$1.06	($0.08)
P	2008	$0.01	$0.37	$0.38	$0.67	$0.95	$0.13	$0.76	$0.94	$1.04	($0.08)
L	2009	$0.01	$0.35	$0.37	$0.41	$0.94	$0.12	$0.63	$0.90	$1.02	($0.08)
A	2010	$0.01	$0.34	$0.34	$0.36	$0.90	$0.01	$0.63	$0.85	$0.78	($0.08)
C	2011	$0.01	$0.33	$0.33	$0.36	$0.89	$0.01	$0.63	$0.85	$0.78	($0.08)
E	2012	$0.01	$0.33	$0.33	$0.35	$0.89	$0.01	$0.62	$0.84	$0.77	($0.08)
D	2013	$0.00	$0.32	$0.32	$0.35	$0.88	$0.00	$0.62	$0.85	$0.77	($0.08)
	2014	$0.00	$0.32	$0.32	$0.35	$0.88	$0.00	$0.61	$0.85	$0.77	($0.08)
		1	4	3	5	9	2	6	8	7	

	YEAR	A. Common Elements Only	B. Ethanol Blending (10%)	C. Ethanol Blending (10%) & Alcohol Vehicle Incentives	D. Alcohol (M85/E85) Fuel & Vehicle Purchase Incentives	E. Alcohol (M85/E85) Fuel & Vehicle Purchase Incentives & Alcohol (10%) Blending	F. Alcohol & Electric Vehicle Purchase Incentives	G. Ethanol Blending (10%) & Vehicle Incentives; Fleet Mandates Later	H. Fleet Mandates & Fuel & Vehicle Incentives	I. Everything	Future No Action
$	1995	($2)	$86,582	$86,589	$87	$180,897	$9	$86,594	$92	$163,540	($11)
	1996	($4)	$92,535	$92,548	$408	$192,854	$49	$99,255	$21,859	$195,594	($33)
P	1997	($4)	$55,275	$55,309	$579	$114,674	$112	$26,921	$4,763	$23,486	($39)
E	1998	$515	$33,553	$33,625	$1,132	$68,566	$728	$11,989	$2,914	$10,504	($44)
R	1999	$233	$16,748	$17,116	$1,598	$34,576	$1,052	$5,774	$1,897	$5,903	($97)
	2000	$84	$5,898	$6,027	$693	$12,378	$376	$4,068	$1,439	$3,894	($53)
A	2001	$49	$3,360	$3,459	$564	$7,141	$273	$2,846	$1,216	$2,873	($44)
F	2002	$29	$2,232	$2,330	$530	$4,826	$262	$2,068	$972	$2,158	($42)
V	2003	$21	$1,536	$1,595	$453	$3,374	$166	$1,514	$836	$1,716	($43)
	2004	$15	$1,100	$1,152	$419	$2,492	$145	$1,253	$562	$1,374	($42)
	2005	$11	$824	$869	$387	$1,940	$126	$975	$526	$1,179	($41)
	2006	$7	$645	$672	$349	$1,555	$80	$857	$492	$1,036	($40)
	2007	$5	$521	$543	$324	$1,300	$66	$730	$473	$937	($38)
	2008	$4	$440	$459	$301	$1,123	$57	$639	$430	$835	($35)
	2009	$3	$391	$408	$179	$1,018	$52	$488	$396	$760	($35)
	2010	$3	$354	$354	$155	$919	$3	$458	$368	$552	($34)
	2011	$2	$325	$324	$149	$856	$2	$428	$358	$522	($33)
	2012	$2	$304	$304	$144	$811	$2	$404	$351	$498	($32)
	2013	$2	$289	$289	$140	$776	$2	$386	$345	$479	($31)
	2014	$2	$280	$280	$136	$756	$2	$373	$339	$464	($31)
		1	5	4	3	9	2	7	6	8	

	YEAR	A	B	C	D	E	F	G	H	I	Future No Action
N	1995	0	2,260	2,260	0	2,260	0	2,260	0	2,695	0
U	1996	0	2,260	2,260	0	2,260	0	2,260	0	2,782	0
M	1997	0	2,347	2,347	0	2,347	0	2,347	4	2,869	0
B	1998	0	2,347	2,347	0	2,347	0	2,347	7	3,043	0
E	1999	0	2,434	2,434	0	2,434	0	2,434	11	3,130	0
R	2000	0	2,434	2,434	4	2,434	0	2,521	15	3,217	0
	2001	4	2,521	2,521	4	2,521	4	2,608	22	3,391	0
O	2002	4	2,521	2,521	7	2,608	4	2,782	29	3,565	4
F	2003	7	2,608	2,608	11	2,695	7	2,869	37	3,738	4
	2004	11	2,695	2,695	18	2,782	11	3,043	1,130	3,912	7
J	2005	15	2,869	2,869	22	2,956	15	3,217	1,391	4,173	11
O	2006	18	2,956	2,956	26	3,043	18	3,391	1,652	4,434	15
B	2007	22	3,043	3,043	33	3,217	22	3,565	1,913	4,695	18
S	2008	26	3,130	3,130	37	3,304	26	3,738	2,174	4,956	18
	2009	29	3,217	3,217	956	3,391	29	3,912	2,347	5,216	22
	2010	29	3,304	3,304	956	3,478	29	4,086	2,608	304	26
	2011	33	3,391	3,391	1,043	3,565	33	4,173	2,782	314	29
	2012	33	3,478	3,478	1,130	3,652	33	4,347	2,956	324	29
	2013	37	3,478	3,478	1,130	3,652	37	4,434	3,130	334	33
	2014	37	3,565	3,565	1,130	3,738	37	4,521	3,217	339	33
		8	3	3	6	2	8	1	5	7	

	YEAR	A. Common Elements Only	B. Ethanol Blending (10%)	C. Ethanol Blending (10%) & Alcohol Vehicle Incentives	D. Alcohol (M85/E85) Fuel & Vehicle Purchase Incentives	E. Alcohol (M85/E85) Fuel & Vehicle Purchase Incentives & Alcohol (10%) Blending	F. Alcohol & Electric Vehicle Purchase Incentives	G. Ethanol Blending (10%) & Vehicle Incentives; Fleet Mandates Later	H. Fleet Mandates & Fuel & Vehicle Incentives	I. Everything	Future No Action
$	1995	($323)	$6,756	$6,756	$15,426	$14,115	$1,599	$6,757	$16,215	$10,702	($1,884)
	1996	($615)	$6,835	$6,837	$68,335	$14,292	$8,101	$7,333	$3,661,967	$11,781	($5,434)
P	1997	($1,083)	$6,643	$6,651	$165,040	$13,914	$31,363	$7,669	$2,042,529	$12,873	($10,310)
E	1998	$239,933	$6,786	$6,810	$548,736	$14,159	$339,538	$8,401	$1,557,035	$13,528	($18,059)
R	1999	$216,545	$6,590	$6,749	$1,579,037	$14,035	$981,179	$7,852	$1,279,261	$13,994	($63,874)
	2000	$225,194	$6,610	$6,765	$528,531	$14,212	$1,005,605	$9,146	$1,179,765	$14,560	($110,573)
J	2001	$62,075	$6,396	$6,596	$758,198	$13,970	$349,003	$10,511	$980,436	$15,036	($157,997)
O	2002	$55,666	$6,405	$6,700	$539,749	$13,830	$501,679	$11,031	$816,872	$14,931	($60,126)
B	2003	$28,711	$6,197	$6,448	$449,557	$13,651	$233,032	$11,183	$749,960	$15,109	($85,704)
	2004	$19,148	$5,995	$6,289	$347,674	$13,641	$188,692	$11,802	$21,125	$14,914	($58,840)
	2005	$14,492	$5,666	$5,981	$358,990	$13,409	$166,035	$11,454	$20,566	$15,383	($51,916)
	2006	$10,123	$5,524	$5,761	$356,159	$13,389	$107,700	$12,126	$20,078	$15,762	($49,939)
	2007	$7,538	$5,389	$5,623	$319,783	$13,145	$92,310	$12,148	$20,097	$16,247	($48,860)
	2008	$6,016	$5,265	$5,495	$317,642	$13,142	$82,032	$12,229	$18,989	$16,191	($56,265)
	2009	$4,855	$5,152	$5,374	$8,198	$13,126	$73,724	$10,406	$18,581	$16,045	($53,105)
	2010	$4,402	$5,046	$5,046	$7,852	$12,849	$4,422	$10,632	$17,393	$223,832	($50,911)
	2011	$3,708	$4,949	$4,948	$7,609	$12,800	$3,724	$10,813	$17,458	$225,692	($48,840)
	2012	$3,560	$4,860	$4,859	$7,308	$12,727	$3,574	$10,756	$17,499	$227,054	($52,329)
	2013	$3,123	$4,898	$4,898	$7,499	$12,879	$3,134	$10,907	$17,465	$227,782	($49,014)
	2014	$3,075	$4,819	$4,819	$7,615	$12,761	$3,085	$11,032	$17,754	$231,164	($50,935)
		1	4	3	5	7	2	6	8	9	

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	YEAR	A	B	C	D	E	F	G	H	I	Future No Action
#	1995	161	160	160	160	160	161	160	160	160	161
	1996	227	217	217	208	208	227	389	649	702	223
O	1997	380	366	366	355	355	381	1,108	2,416	2,502	351
F	1998	726	698	698	675	675	728	2,413	5,234	5,360	561
	1999	1,909	1,784	1,778	1,678	1,678	1,916	4,406	9,178	9,341	1,511
A	2000	3,801	3,698	3,696	3,619	3,619	3,816	7,504	14,280	14,476	3,004
F	2001	5,990	5,937	5,937	5,910	5,910	6,008	12,069	20,483	20,717	4,569
V	2002	8,699	8,800	8,802	8,825	8,825	8,730	17,865	28,008	28,281	6,500
	2003	12,424	12,530	12,542	12,643	12,643	12,476	24,840	36,818	37,132	8,923
	2004	16,991	17,155	17,168	17,370	17,370	17,039	33,154	47,487	47,870	12,298
	2005	22,277	22,517	22,534	22,859	22,859	22,339	42,982	59,960	60,369	16,433
	2006	28,121	28,445	28,472	28,912	28,912	28,200	53,780	73,474	73,903	21,335
	2007	34,124	34,551	34,580	35,201	35,201	34,193	65,726	87,873	88,315	26,672
	2008	39,450	40,059	40,097	40,956	40,956	39,527	77,844	102,398	102,807	31,597
	2009	44,241	44,927	44,966	45,979	45,979	44,319	89,674	116,192	116,571	36,249
	2010	48,914	49,654	49,711	50,855	50,855	49,013	100,677	129,275	129,620	41,063
	2011	53,200	53,929	53,977	55,267	55,267	53,246	111,145	141,442	141,767	45,692
	2012	56,728	57,517	57,559	58,969	58,969	56,766	120,972	152,949	153,248	50,023
	2013	59,556	60,392	60,430	61,943	61,943	59,591	130,027	163,477	163,736	53,698
	2014	61,733	62,594	62,629	64,231	64,231	61,759	138,018	172,865	173,083	56,770

#	YEAR	A. Common Elements Only	B. Ethanol Blending (10%)	C. Ethanol Blending (10%) & Alcohol Vehicle Incentives	D. Alcohol (M85/E85) Fuel & Vehicle Purchase Incentives	E. Alcohol (M85/E85) Fuel & Vehicle Purchase Incentives & Alcohol (10%) Blending	F. Alcohol & Electric Vehicle Purchase Incentives	G. Ethanol Blending (10%) & Vehicle Incentives; Fleet Mandates Later	H. Fleet Mandates & Fuel & Vehicle Incentives	I. Everything	Future No Action
	1995	2	2	2	3	3	2	2	3	3	1
O	1996	8	11	11	14	14	8	225	860	812	2
F	1997	27	37	38	48	48	28	466	1,740	1,644	5
	1998	80	108	111	140	140	80	746	2,645	2,501	12
P	1999	600	755	766	905	905	600	1,095	3,610	3,417	442
R	2000	764	976	988	1,184	1,184	761	2,050	4,609	4,366	466
I	2001	1,001	1,292	1,309	1,585	1,585	1,002	3,189	5,718	5,421	506
V	2002	1,672	1,929	1,954	2,362	2,362	1,673	4,363	6,835	6,487	785
A	2003	2,212	2,547	2,569	3,099	3,099	2,202	5,501	7,980	7,580	1,252
T	2004	2,692	3,092	3,119	3,751	3,751	2,691	6,897	9,683	9,205	1,645
E	2005	3,088	3,536	3,567	4,288	4,288	3,085	8,183	11,461	10,900	2,070
	2006	3,441	3,914	3,938	4,746	4,746	3,426	9,565	13,210	12,572	2,532
A	2007	3,507	3,980	4,004	4,836	4,836	3,502	10,877	14,969	14,255	2,753
L	2008	3,557	4,027	4,052	4,904	4,904	3,551	11,680	15,925	15,179	2,972
C	2009	3,601	4,068	4,093	4,962	4,962	3,594	12,383	16,886	16,110	3,177
O	2010	3,642	4,105	4,105	4,989	4,989	3,610	13,271	17,854	17,049	3,356
H	2011	3,712	4,174	4,174	5,076	5,076	3,712	14,176	18,968	18,124	3,530
O	2012	3,783	4,244	4,244	5,164	5,164	3,783	15,118	20,110	19,227	3,677
L	2013	3,855	4,314	4,314	5,252	5,252	3,855	16,070	21,280	20,358	3,801
	2014	3,928	4,393	4,393	5,342	5,342	3,928	17,059	22,478	21,517	3,907

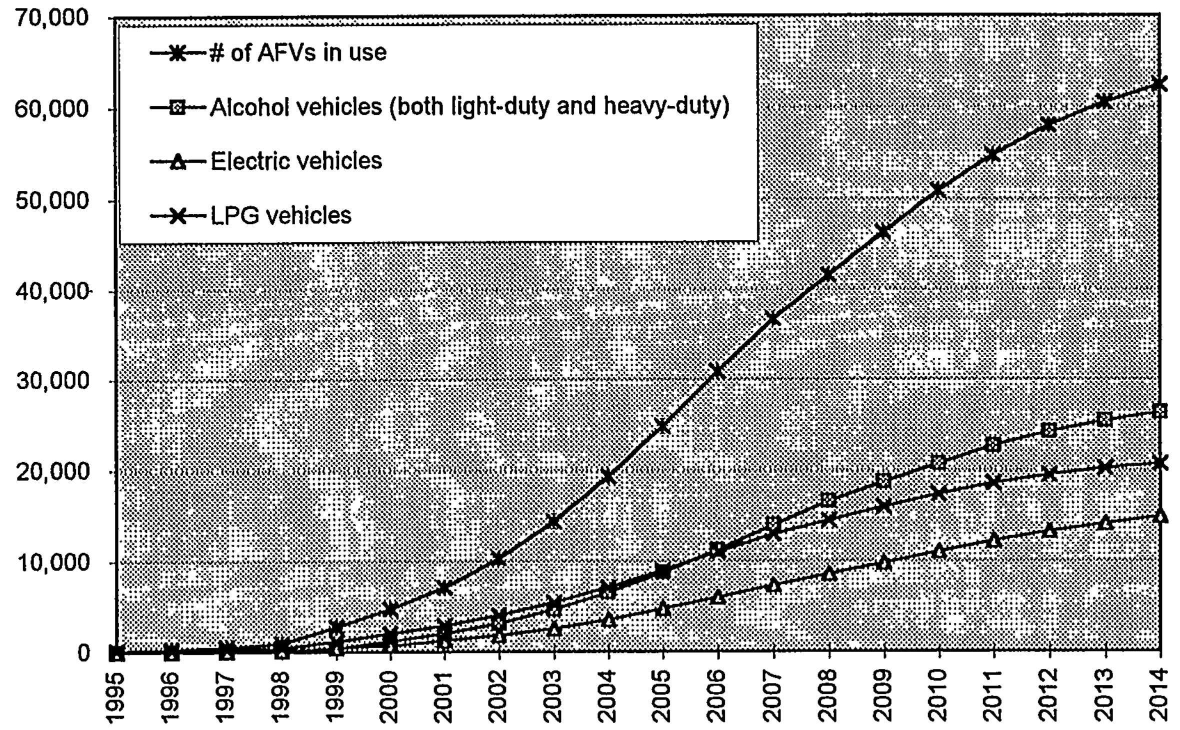
	YEAR	A. Common Elements Only	B. Ethanol Blending (10%)	C. Ethanol Blending (10%) & Alcohol Vehicle Incentives	D. Alcohol (M85/E85) Fuel & Vehicle Purchase Incentives	E. Alcohol (M85/E85) Fuel & Vehicle Purchase Incentives & Alcohol (10%) Blending	F. Alcohol & Electric Vehicle Purchase Incentives	G. Ethanol Blending (10%) & Vehicle Incentives; Fleet Mandates Later	H. Fleet Mandates & Fuel & Vehicle Incentives	I. Everything	Future No Action
O	1995	0	0	0	0	0	0	0	0	0	0
F	1996	2	2	2	2	2	2	42	115	109	1
	1997	8	8	8	7	7	9	97	259	245	1
P	1998	27	24	24	22	22	29	173	441	417	3
R	1999	212	180	178	151	151	230	283	652	617	129
I	2000	298	259	257	223	223	325	583	930	881	150
V	2001	415	366	364	320	320	442	966	1,202	1,139	173
A	2002	626	581	577	508	508	666	1,407	1,544	1,466	285
T	2003	877	814	810	716	716	934	1,915	1,897	1,802	389
E	2004	1,129	1,050	1,045	925	925	1,176	2,492	2,485	2,362	544
	2005	1,384	1,288	1,281	1,133	1,133	1,440	3,213	3,038	2,890	735
E	2006	1,612	1,504	1,499	1,321	1,321	1,679	3,854	3,682	3,504	944
L	2007	1,720	1,609	1,603	1,415	1,415	1,768	4,643	4,388	4,178	1,078
E	2008	1,828	1,714	1,708	1,508	1,508	1,878	5,173	4,914	4,683	1,222
C	2009	1,939	1,822	1,816	1,605	1,605	1,992	5,844	5,488	5,234	1,372
T	2010	2,056	1,936	1,936	1,714	1,714	2,118	6,354	6,114	5,837	1,523
R	2011	2,123	2,002	2,002	1,773	1,773	2,123	6,912	6,608	6,312	1,625
I	2012	2,192	2,070	2,070	1,834	1,834	2,192	7,496	7,131	6,815	1,719
C	2013	2,264	2,141	2,141	1,898	1,898	2,265	8,118	7,684	7,348	1,804
	2014	2,340	2,214	2,214	1,965	1,965	2,340	8,770	8,270	7,912	1,884

	YEAR	A. Common Elements Only	B. Ethanol Blending (10%)	C. Ethanol Blending (10%) & Alcohol Vehicle Incentives	D. Alcohol (M85/E85) Fuel & Vehicle Purchase Incentives	E. Alcohol (M85/E85) Fuel & Vehicle Purchase Incentives & Alcohol (10%) Blending	F. Alcohol & Electric Vehicle Purchase Incentives	G. Ethanol Blending (10%) & Vehicle Incentives; Fleet Mandates Later	H. Fleet Mandates & Fuel & Vehicle Incentives	I. Everything	Future No Action
T	1995	(295)	13,887,963	13,888,153	13,967	28,889,013	1,463	13,891,638	14,684	26,193,150	(1,715)
O	1996	(839)	20,041,993	20,043,960	84,773	40,079,618	11,061	38,602,195	14,195,809	137,269,479	(7,362)
T	1997	(1,472)	20,252,410	20,265,974	205,720	40,712,734	42,676	29,826,249	11,506,474	58,755,475	(13,528)
A	1998	374,155	23,412,682	23,470,131	764,171	46,285,271	530,011	28,925,249	15,250,368	56,297,708	(24,533)
L	1999	444,507	29,878,157	30,433,248	2,680,734	58,003,599	2,014,907	25,443,981	17,408,793	55,140,702	(146,151)
	2000	320,954	21,812,329	22,276,915	2,509,126	44,789,457	1,435,685	30,523,535	20,546,938	56,368,987	(158,187)
C	2001	291,613	19,948,170	20,540,600	3,331,136	42,201,820	1,640,536	34,343,443	24,906,011	59,529,066	(199,282)
O	2002	253,193	19,638,801	20,509,934	4,672,878	42,584,947	2,283,609	36,946,651	27,214,277	61,019,600	(274,784)
S	2003	255,176	19,241,043	20,000,634	5,733,335	42,655,558	2,073,503	37,605,320	30,775,838	63,729,881	(380,726)
T	2004	249,885	18,866,867	19,776,389	7,269,800	43,283,219	2,462,506	41,532,473	26,709,250	65,771,120	(517,499)
S	2005	245,926	18,562,242	19,576,417	8,836,064	44,345,257	2,818,424	41,920,068	31,511,301	71,154,686	(670,611)
	2006	210,839	18,347,179	19,124,264	10,087,213	44,958,008	2,244,258	46,082,454	36,156,412	76,595,930	(847,606)
	2007	183,588	18,001,896	18,775,784	11,419,197	45,755,209	2,248,083	47,997,791	41,531,825	82,780,959	(1,009,184)
	2008	165,908	17,630,475	18,398,133	12,339,014	45,997,515	2,262,594	49,761,052	44,011,733	85,855,588	(1,120,982)
	2009	151,616	17,585,288	18,339,021	8,246,344	46,811,206	2,302,393	43,759,000	46,068,247	88,649,204	(1,258,680)
	2010	136,524	17,577,997	17,579,372	7,858,312	46,758,343	137,202	46,150,388	47,569,648	71,546,773	(1,399,324)
	2011	128,022	17,504,501	17,506,452	8,232,493	47,315,484	128,500	47,546,473	50,597,710	73,956,098	(1,514,813)
	2012	121,764	17,479,486	17,481,264	8,502,843	47,840,238	122,182	48,929,218	53,618,817	76,323,199	(1,609,893)
	2013	117,677	17,482,916	17,485,136	8,668,475	48,096,752	118,049	50,250,798	56,338,525	78,412,182	(1,679,937)
	2014	115,124	17,525,050	17,528,000	8,759,136	48,547,776	115,435	51,508,991	58,605,714	80,371,753	(1,731,582)
		1	4	5	3	6	2	7	8	9	

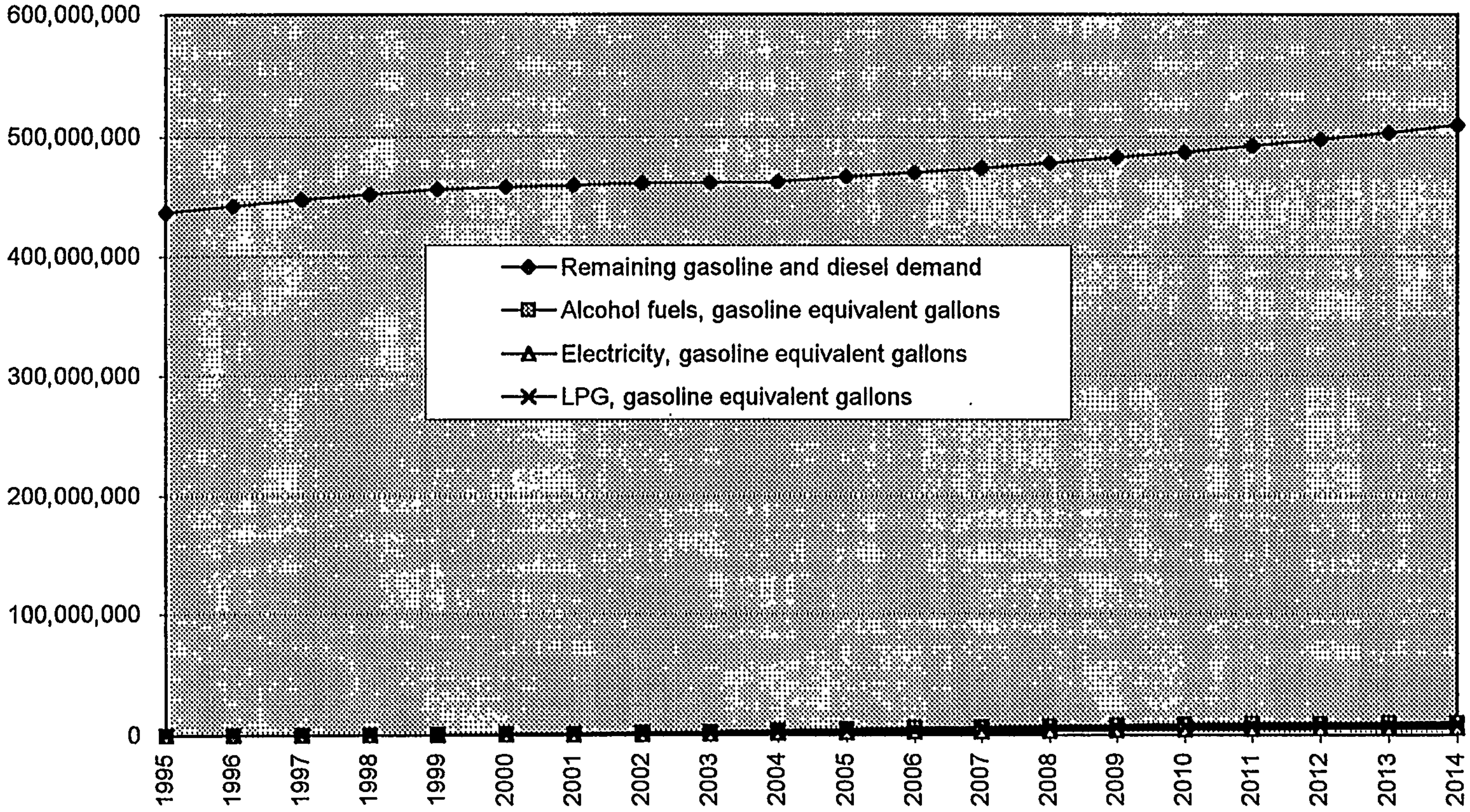
SAMPLE DETAIL FROM AN EVALUATION RUN

(APPENDIX A-4 cont'd)

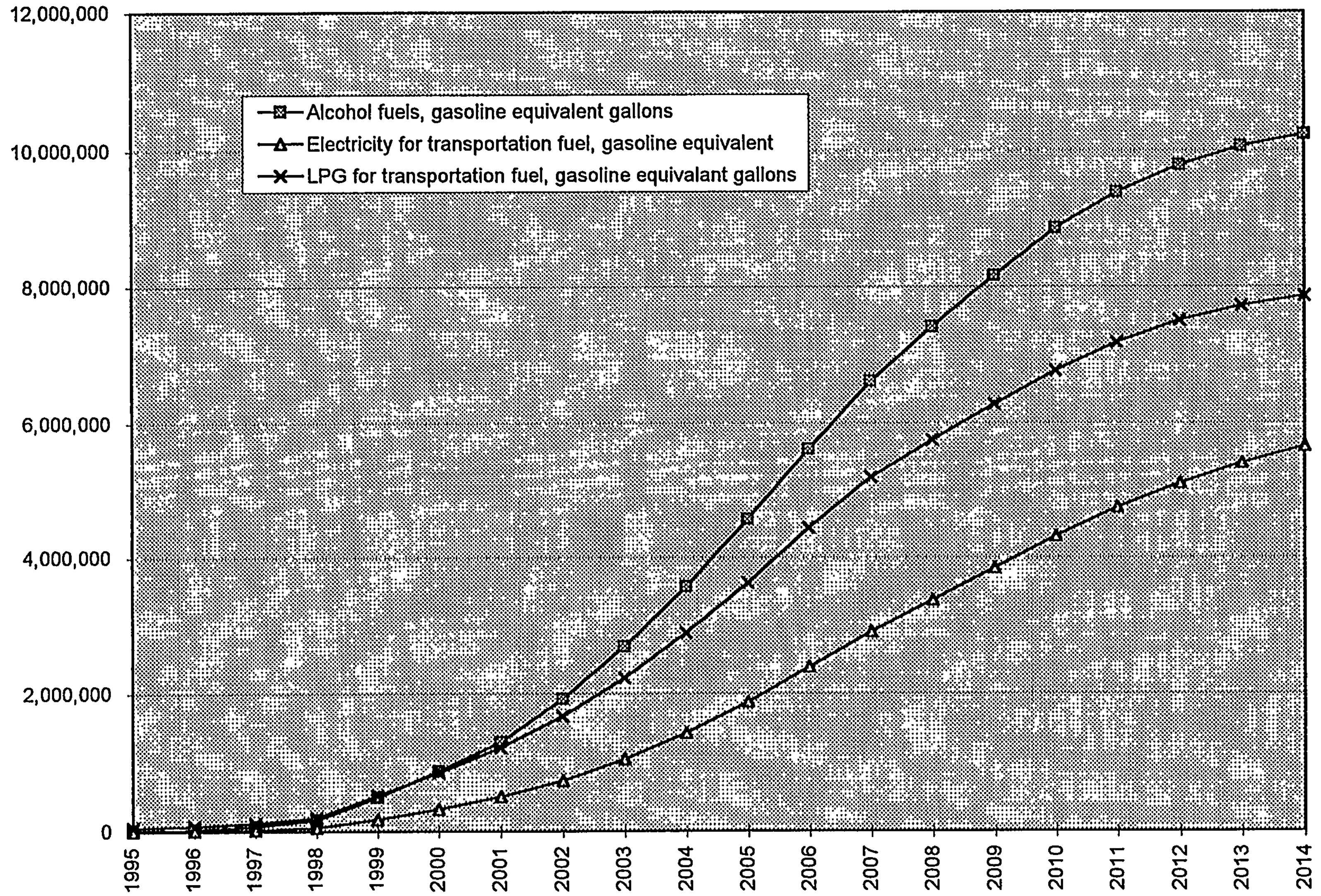
PROJECTED NUMBER OF AFVS



NUMBER OF ALTERNATIVE FUEL VEHICLES projected with parameters in scenario run of 8/1/95, 10:57 AM



TRANSPORTATION FUEL DEMAND, scenario run of 8/1/95, 10:57 AM



PROJECTED DEMAND FOR ALTERNATIVE FUELS, scenario run of 8/1/95, 10:57 AM

Projected Use of Alternative Transportation Fuels

Year	Alcohol fuels: If all alcohol fuel is methanol (gallons)	Alcohol fuels: If all alcohol fuel · is ethanol (gallons)	Electricity (kWh)	LPG (gallons)
1995	18,166	13,577	63,401	77,747
1996	74,860	49,062	104,257	106,272
1997	161,755	106,012	175,680	152,080
1998	367,722	240,999	377,835	267,202
1999	1,127,018	738,630	1,190,991	687,525
2000	1,979,762	1,297,506	2,205,141	1,141,853
2001	2,954,194	1,936,133	3,444,328	1,637,842
2002	4,411,650	2,891,327	5,064,173	2,249,772
2003	6,154,871	4,033,808	7,178,268	3,011,068
2004	8,187,021	5,365,648	9,825,860	3,907,565
2005	10,433,396	6,837,887	12,996,777	4,908,137
2006	12,857,833	8,426,826	16,566,850	5,995,128
2007	15,142,241	9,923,992	20,160,317	7,012,497
2008	16,949,204	11,108,248	23,398,389	7,770,202
2009	18,651,990	12,224,228	26,627,731	8,481,463
2010	20,248,854	13,270,787	29,867,935	9,151,321
2011	21,465,598	14,068,223	32,769,233	9,708,477
2012	22,386,965	14,672,072	35,288,951	10,133,380
2013	23,018,122	15,085,723	37,390,112	10,422,872
2014	23,419,807	15,348,981	39,092,668	10,603,229

PROJECTED DEMAND FOR ALTERNATIVE TRANSPORTATION FUELS, with parameters in scenario run of 8/1/95, 10:58 AM

Gasoline and Diesel Displaced by Alternative Fuels

Year	Remaining Gasoline and Diesel Demand (GEG/year)	Alcohol Fuels (GEG*/year)	Electricity (GEG*/year)	LPG (GEG*/year)
1995	436,501,371	9,051	9,153	57,540
1996	442,299,514	32,708	15,051	78,651
1997	447,087,515	70,675	25,363	112,552
1998	451,769,932	160,666	54,547	197,753
1999	455,911,808	492,420	171,941	508,829
2000	457,853,969	865,004	318,352	845,072
2001	459,606,759	1,290,756	497,252	1,212,147
2002	460,930,787	1,927,552	731,106	1,665,029
2003	461,866,895	2,689,205	1,036,314	2,228,455
2004	462,414,173	3,577,099	1,418,543	2,891,941
2005	466,262,718	4,558,591	1,876,323	3,632,452
2006	469,963,852	5,617,884	2,391,728	4,436,920
2007	473,825,935	6,615,994	2,910,511	5,189,863
2008	478,191,336	7,405,499	3,377,986	5,750,631
2009	482,688,693	8,149,485	3,844,200	6,277,026
2010	487,311,744	8,847,191	4,311,983	6,772,780
2011	492,283,052	9,378,815	4,730,838	7,185,125
2012	497,585,679	9,781,382	5,094,606	7,499,590
2013	503,224,456	10,057,149	5,397,947	7,713,840
2014	509,149,891	10,232,654	5,643,742	7,847,320

* GEG = "Gasoline equivalent gallons"

GASOLINE EQUIVALENT GALLONS OF ALTERNATIVE TRANSPORTATION FUELS, with parameters in scenario run of 8/1/95, 10:58 AM

COST

Year	Additional costs		Cost-effectiveness			
	..to motorists/public (fees, taxes, and / or excise tax revenue reductions)	..imposed by state regulation on AFV owners / operators (including state gov't fleets)	Average cost per GEG displaced	Average cost per alternative fuel vehicle	Additional annual employ-ment	Cost per job
1995	($323)	$0	($0.00)	($2)	0	($323)
1996	($615)	$0	($0.00)	($4)	0	($615)
1997	($1,083)	$0	($0.01)	($4)	0	($1,083)
1998	($2,213)	$242,146	$0.58	$515	0	$239,933
1999	($6,368)	$222,913	$0.18	$233	0	$216,545
2000	($10,978)	$236,172	$0.11	$84	0	$225,194
2001	($16,173)	$243,804	$0.08	$49	4	$62,075
2002	($23,533)	$227,661	$0.05	$29	4	$55,666
2003	($32,428)	$242,988	$0.04	$21	7	$28,711
2004	($42,826)	$253,464	$0.03	$15	11	$19,148
2005	($54,351)	$266,909	$0.02	$11	15	$14,492
2006	($66,811)	$252,400	$0.01	$7	18	$10,123
2007	($78,530)	$244,379	$0.01	$5	22	$7,538
2008	($87,651)	$242,061	$0.01	$4	26	$6,016
2009	($96,238)	$238,653	$0.01	$3	29	$4,855
2010	($104,299)	$233,425	$0.01	$3	29	$4,402
2011	($110,590)	$232,955	$0.01	$2	33	$3,708
2012	($115,362)	$232,854	$0.01	$2	33	$3,560
2013	($118,627)	$233,139	$0.00	$2	37	$3,123
2014	($120,692)	$233,461	$0.00	$2	37	$3,075

COSTS projected with parameters in scenario run of 8/1/95, 10:58 AM

Special Fund for Alternative Fuel Incentives

A.4 Increase Taxes on Gasoline and Diesel Fuel

Measure	Increase Taxes on Gasoline and Diesel Fuel	# of AFVs		# of gasoline & diesel vehicles		Gasoline and diesel subject to additional tax (GEG per year of all blends usable in conventional vehicles)		Additional tax rate	$ / yr to alternative fuel fund		% increase / yr in # of AFVs	% increase / yr in # of gasoline & diesel vehicles	Fuel per vehicle (GEG)	Alternative fuel taxes ($/GEG) if equivalent to diesel rate	Amount paid by alcohol fueled vehicles ($/GEG)	Amount paid by electric vehicles	Amount paid by LPG vehicles ($/GEG)	Total paid by AFVs	Value of incentives
"on" (1)	Year	from	to	from	to	from	to	($/gal)	from	to				$0.29	$0.29	$0.00	$0.29		
or	1995	176	166	940,222	959,183	427,872,577	436,501,371	$0.000	$0	$0	-5.63%	2.02%	455.08	$18,978	$2,657	$0	$16,644	$19,301	($323)
"off" (0):	1996	166	280	959,183	978,403	433,610,872	442,299,514	$0.000	$0	$0	68.00%	2.00%	452.06	$31,737	$9,600	$0	$22,751	$32,352	($615)
0	1997	280	466	978,403	997,940	438,334,810	447,087,515	$0.000	$0	$0	66.50%	2.00%	448.01	$52,220	$20,744	$0	$32,558	$53,302	($1,083)
	1998	466	930	997,940	1,017,595	443,043,643	451,769,932	$0.000	$0	$0	99.79%	1.97%	443.96	$102,150	$47,159	$0	$57,204	$104,363	($2,213)
	1999	930	2,667	1,017,595	1,036,384	447,646,411	455,911,808	$0.000	$0	$0	186.71%	1.85%	439.91	$285,356	$144,535	$0	$147,189	$291,724	($6,368)
	2000	2,667	4,675	1,036,384	1,055,315	449,640,694	457,853,969	$0.000	$0	$0	75.31%	1.83%	433.86	$487,371	$253,896	$0	$244,454	$498,350	($10,978)
	2001	4,675	7,013	1,055,315	1,074,339	451,468,304	459,606,759	$0.000	$0	$0	50.00%	1.80%	427.80	$713,327	$378,863	$0	$350,637	$729,500	($16,173)
	2002	7,013	10,252	1,074,339	1,092,892	453,105,982	460,930,787	$0.000	$0	$0	46.18%	1.73%	421.75	$1,023,885	$565,776	$0	$481,643	$1,047,418	($23,533)
	2003	10,252	14,323	1,092,892	1,111,052	454,317,746	461,866,895	$0.000	$0	$0	39.71%	1.66%	415.70	$1,401,633	$789,336	$0	$644,625	$1,433,961	($32,428)
	2004	14,323	19,254	1,111,052	1,128,799	455,143,969	462,414,173	$0.000	$0	$0	34.43%	1.60%	409.65	$1,843,676	$1,049,951	$0	$836,651	$1,886,502	($42,826)
	2005	19,254	24,753	1,128,799	1,146,436	459,089,646	466,262,718	$0.000	$0	$0	28.56%	1.56%	406.71	$2,334,447	$1,338,039	$0	$1,050,759	$2,388,798	($54,351)
	2006	24,753	30,826	1,146,436	1,163,966	462,886,247	469,963,852	$0.000	$0	$0	24.53%	1.53%	403.76	$2,865,619	$1,648,963	$0	$1,283,467	$2,932,430	($66,811)
	2007	30,826	36,716	1,163,966	1,182,154	466,535,754	473,825,935	$0.000	$0	$0	19.11%	1.56%	400.82	$3,364,669	$1,941,929	$0	$1,601,270	$3,443,199	($78,530)
	2008	36,716	41,557	1,182,154	1,201,877	470,344,269	478,191,336	$0.000	$0	$0	13.18%	1.67%	397.87	$3,749,497	$2,173,665	$0	$1,663,484	$3,837,148	($87,651)
	2009	41,657	46,264	1,201,877	1,222,227	474,651,583	482,688,693	$0.000	$0	$0	11.33%	1.69%	394.93	$4,111,556	$2,392,040	$0	$1,815,754	$4,207,794	($96,238)
	2010	46,264	50,849	1,222,227	1,243,205	479,089,003	487,311,744	$0.000	$0	$0	9.91%	1.72%	391.98	$4,451,692	$2,596,831	$0	$1,959,160	$4,555,991	($104,299)
	2011	50,849	54,737	1,243,205	1,265,395	483,650,271	492,283,052	$0.000	$0	$0	7.65%	1.78%	389.04	$4,720,723	$2,752,873	$0	$2,078,439	$4,831,312	($110,690)
	2012	54,737	57,954	1,265,395	1,288,782	488,656,224	497,585,679	$0.000	$0	$0	5.88%	1.85%	386.09	$4,925,077	$2,871,035	$0	$2,169,405	$5,040,439	($115,362)
	2013	57,954	60,470	1,288,782	1,313,406	493,789,973	503,224,456	$0.000	$0	$0	4.34%	1.91%	383.14	$5,064,732	$2,951,978	$0	$2,231,381	$5,183,358	($118,627)
	2014	60,470	62,398	1,313,406	1,339,165	499,356,228	509,149,891	$0.000	$0	$0	3.19%	1.96%	380.20	$5,152,793	$3,003,492	$0	$2,269,992	$5,273,485	($120,692)
	beyond 2014	60,470	62,398	1,313,406	1,339,165	499,356,228	509,149,891												

	Increased tax on gasoline and diesel	# of AFVs in use		Fuel used per vehicle	Transition to next phase	AFVs as % of total vehicles	¢/gal (multipliers) per phase	vehicle fee (multipliers) per phase	# of AFVs by type			Proposed rates of tax on gasoline and diesel
	$/gallon	from	to	(GEG/yr)	Year		0.001	0.250	alcohol	electric	LPG	$/gallon
Phase 1	$0.0000	176	2,667	455	1999	0%	0.500	1.001	1,119	391	1,157	$0.001
Phase 2	$0.0000	2,667	10,252	440	2002	1%	0.501	1.001	4,570	1,733	3,948	$0.000
Phase 3	$0.0000	10,252	24,753	422	2005	2%	0.501	1.001	11,209	4,613	8,931	$0.000
Phase 4	$0.0000	24,753	46,264	407	2009	4%	0.501	1.001	20,636	9,734	15,894	$0.000
Phase 5	$0.0000	46,264	–	395	–	–	0.501	1.001	–	–	–	$0.000

Special Fund for Alternative Fuel Incentives

A.7.A Alcohol Producer Payments

Measure	Alcohol Producer Payments	# of AFVs in use		Alcohol vehicles (both light-duty and heavy-duty)		Alcohol fuels (GEG/yr)		Phase		$/yr from alternative fuel fund		$/year remaining in alternative fuel fund		% of annual amount >$0 forwarded to other measures
"on" (1)		from	to	from	to	from	to	Phase (alcohol	rate ($/GEG)	from	to	annual	cumulative	0%
or	1995	176	166	15	20	6,690	9,051	1	$0.00	($323)	($323)	$323	$323	$0
"off" (0):	1996	166	280	20	72	9,051	32,708	1	$0.00	($615)	($615)	$615	$937	$0
0	1997	280	466	72	158	32,708	70,675	1	$0.00	($1,083)	($1,083)	$1,083	$2,020	$0
	1998	466	930	158	362	70,675	160,666	1	$0.00	($2,213)	($2,213)	$2,213	$4,233	$0
	1999	930	2,667	362	1,119	160,666	492,420	1	$0.00	($6,368)	($6,368)	$6,368	$10,602	$0
	2000	2,667	4,675	1,119	1,994	492,420	865,004	1	$0.00	($10,978)	($10,978)	$10,978	$21,580	$0
	2001	4,675	7,013	1,994	3,017	865,004	1,290,756	2	$0.00	($16,173)	($16,173)	$16,173	$37,753	$0
	2002	7,013	10,252	3,017	4,570	1,290,756	1,927,552	2	$0.00	($23,533)	($23,533)	$23,533	$61,286	$0
	2003	10,252	14,323	4,570	6,469	1,927,552	2,689,205	2	$0.00	($32,428)	($32,428)	$32,428	$93,714	$0
	2004	14,323	19,254	6,469	8,732	2,689,205	3,577,099	2	$0.00	($42,826)	($42,826)	$42,826	$136,540	$0
	2005	19,254	24,753	8,732	11,209	3,577,099	4,558,591	2	$0.00	($54,351)	($54,351)	$54,351	$190,890	$0
	2006	24,753	30,826	11,209	13,914	4,558,591	5,617,884	2	$0.00	($66,811)	($66,811)	$66,811	$257,701	$0
	2007	30,826	36,716	13,914	16,506	5,617,884	6,615,994	2	$0.00	($78,530)	($78,530)	$78,530	$336,231	$0
	2008	36,716	41,557	16,506	18,613	6,615,994	7,405,499	2	$0.00	($87,651)	($87,651)	$87,651	$423,883	$0
	2009	41,557	46,264	18,613	20,636	7,405,499	8,149,485	2	$0.00	($96,238)	($96,238)	$96,238	$520,120	$0
	2010	46,264	50,849	20,636	22,571	8,149,485	8,847,191	2	$0.00	($104,299)	($104,299)	$104,299	$624,420	$0
	2011	50,849	54,737	22,571	24,108	8,847,191	9,378,815	2	$0.00	($110,590)	($110,590)	$110,590	$735,009	$0
	2012	54,737	57,954	24,108	25,334	9,378,815	9,781,382	2	$0.00	($115,362)	($115,362)	$115,362	$850,372	$0
	2013	57,954	60,470	25,334	26,249	9,781,382	10,057,149	2	$0.00	($118,627)	($118,627)	$118,627	$968,998	$0
	2014	60,470	62,398	26,249	26,914	10,057,149	10,232,654	2	$0.00	($120,692)	($120,692)	$120,692	$1,089,690	$0
	beyond 2014	60,470	62,398	26,249	26,914	10,057,149	10,232,654	2	$0.00	($120,692)	($120,692)	$120,692	$1,089,690	MAX
													$323	MIN

MISCELLANEOUS INFO USED ELSEWHERE

	JOBS	Alcohol production cost	= __ gallons ethanol demand	Electric vehicles	LPG vehicles	Proposed alc prod inc rate
		($/GEG)				($/GEG)
1995	0	$2.90	13,577	20	126	#####
1996	0	$2.90	49,062	33	174	#####
1997	0	$2.90	106,012	57	251	#####
1998	0	$2.90	240,999	123	445	#####
1999	0	$2.90	738,630	391	1,157	#####
2000	0	$2.90	1,297,506	734	1,948	#####
2001	4	$2.59	1,936,133	1,162	2,833	#####
2002	4	$2.59	2,891,327	1,733	3,948	#####
2003	7	$2.59	4,033,808	2,493	5,361	#####
2004	11	$2.59	5,365,648	3,463	7,060	#####
2005	15	$2.59	6,837,887	4,613	8,931	#####
2006	18	$2.59	8,426,826	5,924	10,989	#####
2007	22	$2.59	9,923,992	7,261	12,948	#####
2008	26	$2.59	11,108,248	8,490	14,454	#####
2009	29	$2.59	12,224,228	9,734	15,894	#####
2010	29	$2.59	13,270,787	11,001	17,278	#####
2011	33	$2.59	14,068,223	12,160	18,469	#####
2012	33	$2.59	14,672,072	13,195	19,424	#####
2013	37	$2.59	15,085,723	14,089	20,133	#####
2014	37	$2.59	15,348,981	14,844	20,640	#####
beyond 2014	37	$2.59	15,348,981	14,844	20,640	#####
		ml/yr	8,805			

A.10 State Purchase and Distribution of Small Volumes of Alcohol

Phase	Cost	Alcohol fuels (GEG/yr)		Gallons / year methanol demand		Gallons / year ethanol demand	
(alcohol)	($/GEG)	from	to	from	to	from	to
1	$1.38	0	674,716	0	1,000,000	0	800,245
2	$1.06	674,716	10,120,743	1,000,000	15,000,000	800,245	12,003,672

Establish a Special Fund for AFV Incentives

A.18 Registration Fee Surcharge on Conventional Vehicles

Measure	Increased fees on gasoline and diesel vehicles	# of privately owned AFV		# of gasoline & diesel vehicles paying registration fees		Additional fees	$/yr to alternative fuel vehicle fund	
"on" (1)	$/vehicle/y	from	to	from	to	($/vehicle/yr)	from	to
or	1995	139	128	922,041	921,913	$0.000	$0	$0
"off" (0):	1996	128	142	940,635	940,494	$0.000	$0	$0
0	1997	142	189	959,484	959,295	$0.000	$0	$0
	1998	189	335	978,643	978,308	$0.000	$0	$0
	1999	335	1,614	997,918	996,305	$0.000	$0	$0
	2000	1,614	3,154	1,016,344	1,013,190	$0.000	$0	$0
	2001	3,154	5,111	1,034,909	1,029,798	$0.000	$0	$0
	2002	5,111	7,974	1,053,565	1,045,591	$0.000	$0	$0
	2003	7,974	11,713	1,071,759	1,060,046	$0.000	$0	$0
	2004	11,713	16,330	1,089,568	1,073,238	$0.000	$0	$0
	2005	16,330	21,496	1,106,972	1,085,476	$0.000	$0	$0
	2006	21,496	27,317	1,124,268	1,096,951	$0.000	$0	$0
	2007	27,317	32,975	1,141,458	1,108,483	$0.000	$0	$0
	2008	32,975	37,582	1,159,295	1,121,713	$0.000	$0	$0
	2009	37,582	42,124	1,178,636	1,136,512	$0.000	$0	$0
	2010	42,124	46,559	1,198,594	1,152,035	$0.000	$0	$0
	2011	46,559	50,311	1,219,165	1,168,855	$0.000	$0	$0
	2012	50,311	53,406	1,240,927	1,187,521	$0.000	$0	$0
	2013	53,406	55,814	1,263,861	1,208,047	$0.000	$0	$0
	2014	55,814	57,648	1,288,009	1,230,361	$0.000	$0	$0
	beyond 2014	55,814	57,648	1,288,009	1,230,361	0	0	

	Increased fees on gasoline and diesel vehicles	# of AFVs		Transition to next phase	AFVs as % of total vehicles
	$/vehicle/y	from	to	Year	
Phase 1	$0.00	176	2,667	1999	0%
Phase 2	$0.00	2,667	10,252	2002	1%
Phase 3	$0.00	10,252	24,753	2005	2%
Phase 4	$0.00	24,753	46,264	2009	4%
Phase 5	$0.00	46,264	--	--	--

<<--note: same transition years as changes in gasoline & diesel tax rates

A.19 AFV Purchase / Conversion Incentives

Measure	AFV Purchase / Conversion Incentives	Purchase of new alcohol vehicles by private fleets, rental fleets, and individual purchasers			Purchase of new electric vehicles by private fleets, rental fleets, and individual purchasers			Total paid out from AFV fund			
"on" (1)	Beginning amount / vehicle	$500	$500	$5,000	$0	$0	$0	$/yr	$/year remaining in AFV fund		% of annual amount >$0 forwarded to other measures
or	Year	Cars	Light trucks	Heavy Duty	Cars	Light trucks	Heavy Duty		annual	cumulative	0%
"off" (0):	1995	2	0	0	0	0	0	$0	$0	$0	$0
0	1996	7	1	0	2	0	0	$0	$0	$0	$0
	1997	25	2	0	8	1	0	$0	$0	$0	$0
	1998	72	7	0	24	2	0	$0	$0	$0	$0
	1999	417	183	1	148	63	0	$0	$0	$0	$0
	2000	578	185	1	227	71	0	$0	$0	$0	$0
	2001	809	189	2	338	76	1	$0	$0	$0	$0
	2002	1,352	317	4	509	116	1	$0	$0	$0	$0
	2003	1,781	426	5	709	165	2	$0	$0	$0	$0
	2004	2,149	537	6	905	221	2	$0	$0	$0	$0
	2005	2,433	649	6	1,095	286	3	$0	$0	$0	$0
	2006	2,671	764	7	1,256	353	3	$0	$0	$0	$0
	2007	2,727	773	7	1,342	375	3	$0	$0	$0	$0
	2008	2,769	782	7	1,427	397	3	$0	$0	$0	$0
	2009	2,804	790	7	1,514	421	4	$0	$0	$0	$0
	2010	2,837	798	7	1,606	447	4	$0	$0	$0	$0
	2011	2,893	813	7	1,658	461	4	$0	$0	$0	$0
	2012	2,949	827	7	1,713	475	4	$0	$0	$0	$0
	2013	3,006	842	7	1,770	490	4	$0	$0	$0	$0
	2014	3,064	856	7	1,829	506	4	$0	$0	$0	$0
	beyond 2014	3,064	856	7	1,829	506	4	0	0	$0	MAX
										$0	MIN

Proposed AFV tax credit phase-outs					
	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5
Year of tra	1999	2002	2005	2009	–
% of original tax credit	100%	75%	50%	35%	0%

<<--note: same years as changes in gasoline & diesel tax rates

O.2 Public Education

Measure	Time -> diffusion = 15 years		
"on" (1)	15	# of AFVs	
or	Year	from	to
"off" (0):	1995	176	166
1	1996	166	280
	1997	280	466
	1998	466	930
	1999	930	2,667
	2000	2,667	4,675
	2001	4,675	7,013
	2002	7,013	10,252
	2003	10,252	14,323
	2004	14,323	19,254
	2005	19,254	24,763
	2006	24,763	30,826
	2007	30,826	36,716
	2008	36,716	41,557
	2009	41,557	46,264
	2010	46,264	50,849
	2011	50,849	54,737
	2012	54,737	57,954
	2013	57,954	60,470
	2014	60,470	62,398
	beyond 2014	60,470	62,398

G.2 Implement Act 199, 1994 State Legislature

Measure "on" (1) or "off" (0): 0	0.0%	0.0%	0.0%			Btu ratio: 1.000		Btu ratio: 1.000		Btu ratio: 1.000		Assumption for use in phasin alcohol production credits:		Value of State Excise Ta Exemption Assumes 10% blend in 0% of gasoline
	Alcohol blended at avg. rate of % with gasoline					Alcohol blended at avg. rate of 0% with gasoline		Alcohol blended at avg. rate of 0% with gasoline		Alcohol blended at avg. rate of 0% with gasoline		Alcohol blended with gasoline at ra 0.0%		
		# of AFVs		GEG gasoline blend		gallons ethanol		gallons ethanol		gallons ethanol		GEG alcohol		
	Year	from	to	from	to	from	to	from	to	from	to	from	to	
	1995	176	166	399,148,516	407,198,039	0	0	0	0	0	0	0	0	$0
	1996	166	280	403,899,566	411,992,857	0	0	0	0	0	0	0	0	$0
	1997	280	466	407,691,239	415,832,051	0	0	0	0	0	0	0	0	$0
	1998	466	930	411,455,766	419,559,893	0	0	0	0	0	0	0	0	$0
	1999	930	2,667	415,108,862	422,773,482	0	0	0	0	0	0	0	0	$0
	2000	2,667	4,675	416,333,913	423,938,797	0	0	0	0	0	0	0	0	$0
	2001	4,676	7,013	417,399,333	424,923,639	0	0	0	0	0	0	0	0	$0
	2002	7,013	10,252	418,284,341	425,507,802	0	0	0	0	0	0	0	0	$0
	2003	10,252	14,323	418,772,211	425,730,719	0	0	0	0	0	0	0	0	$0
	2004	14,323	19,254	418,901,875	425,593,169	0	0	0	0	0	0	0	0	$0
	2005	19,254	24,753	421,895,973	428,487,909	0	0	0	0	0	0	0	0	$0
	2006	24,753	30,826	424,742,322	431,236,701	0	0	0	0	0	0	0	0	$0
	2007	30,826	36,716	427,443,362	434,122,677	0	0	0	0	0	0	0	0	$0
	2008	36,716	41,557	430,279,730	437,458,374	0	0	0	0	0	0	0	0	$0
	2009	41,557	46,264	433,561,142	440,902,481	0	0	0	0	0	0	0	0	$0
	2010	46,264	50,849	436,949,254	444,448,739	0	0	0	0	0	0	0	0	$0
	2011	50,849	54,737	440,437,829	448,299,301	0	0	0	0	0	0	0	0	$0
	2012	54,737	57,954	444,227,148	452,437,316	0	0	0	0	0	0	0	0	$0
	2013	57,954	60,470	448,300,441	456,865,790	0	0	0	0	0	0	0	0	$0
	2014	60,470	62,398	452,660,616	461,538,457	0	0	0	0	0	0	0	0	$0
	beyond 2014	60,470	62,398	452,660,616	461,538,457	0	0	0	0	0	0	0	0	0

If methanol used
in MTBE

0.339	gal meth/gal MTBE
15%	max % MTBE in gasoline
0.051	max % methanol (in MTBE) in gasoline

A.9 **Ethanol Blending in Diesel ("Diesohol")**

Measure "on" (1) or "off" (0): 0

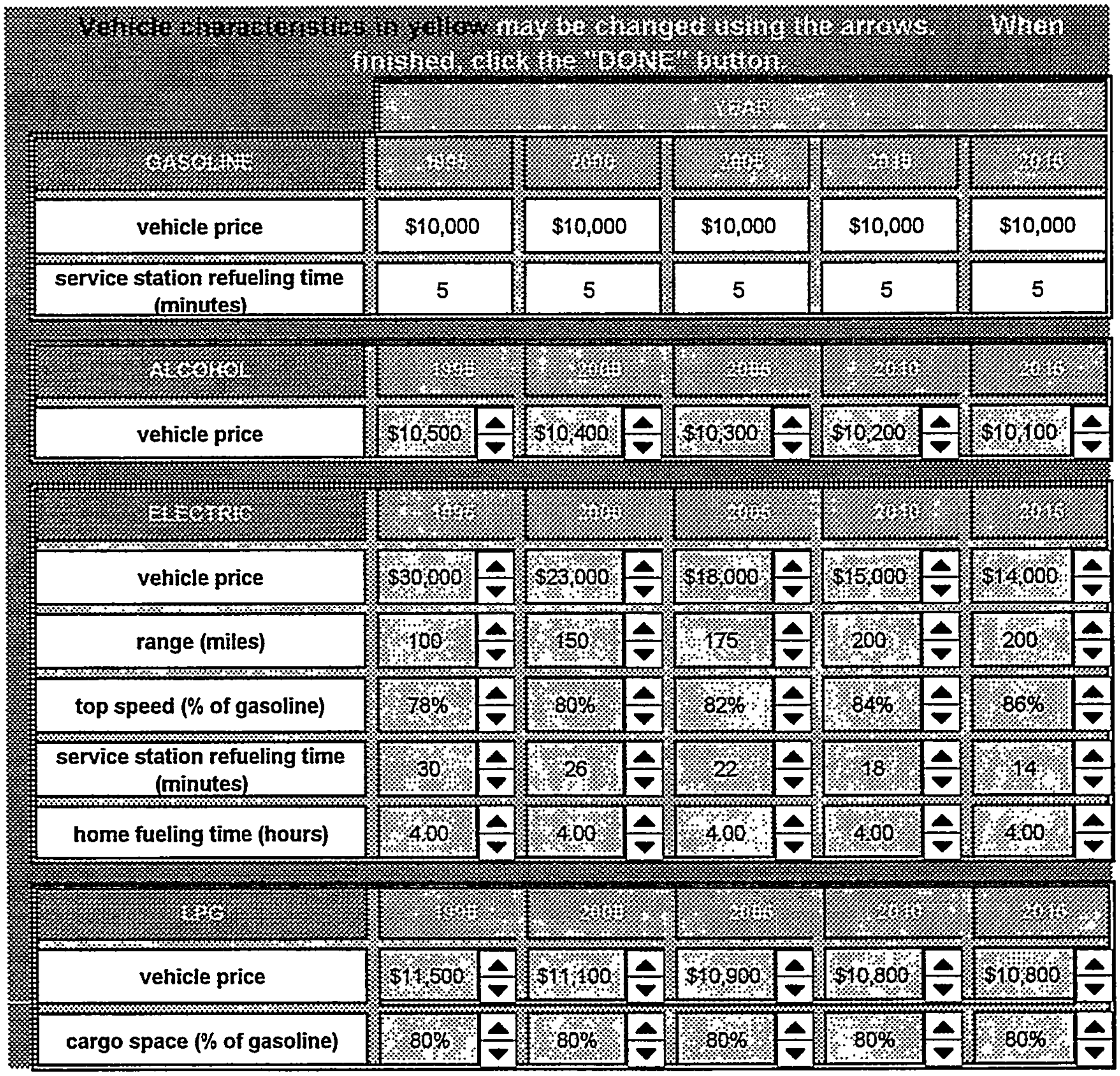
0.0%	0.0%	0.0%			Btu ratio: 1.000		Btu ratio: 1.000		Btu ratio: 1.000	
Ethanol blended at avg. rate of % with diesel					Ethanol blended at avg. rate of 0% with diesel		Ethanol blended at avg. rate of 0% with diesel		Ethanol blended at avg. rate of 0% with diesel	
	# of AFVs		GEG diesel blend		gallons ethanol		gallons ethanol		gallons ethanol	
Year	from	to	from	to	from	to	from	to	from	to
1995	176	166	28,724,061	29,303,332	0	0	0	0	0	0
1996	166	280	29,711,306	30,306,657	0	0	0	0	0	0
1997	280	466	30,643,571	31,255,464	0	0	0	0	0	0
1998	466	930	31,587,877	32,210,039	0	0	0	0	0	0
1999	930	2,667	32,537,549	33,138,326	0	0	0	0	0	0
2000	2,667	4,675	33,306,780	33,915,172	0	0	0	0	0	0
2001	4,676	7,013	34,068,972	34,683,121	0	0	0	0	0	0
2002	7,013	10,252	34,821,641	35,422,985	0	0	0	0	0	0
2003	10,252	14,323	35,545,535	36,136,176	0	0	0	0	0	0
2004	14,323	19,254	36,242,094	36,821,004	0	0	0	0	0	0
2005	19,254	24,753	37,193,674	37,774,808	0	0	0	0	0	0
2006	24,753	30,826	38,143,925	38,727,151	0	0	0	0	0	0
2007	30,826	36,716	39,092,393	39,703,258	0	0	0	0	0	0
2008	36,716	41,557	40,064,539	40,732,962	0	0	0	0	0	0
2009	41,557	46,264	41,090,441	41,786,212	0	0	0	0	0	0
2010	46,264	50,849	42,139,748	42,863,005	0	0	0	0	0	0
2011	60,849	54,737	43,212,442	43,983,751	0	0	0	0	0	0
2012	54,737	57,954	44,329,077	45,148,363	0	0	0	0	0	0
2013	57,954	60,470	45,489,531	46,358,667	0	0	0	0	0	0
2014	60,470	62,398	46,695,613	47,611,434	0	0	0	0	0	0

Assumption for use in phasing alcohol production credits:

Ethanol blended with diesel at rate:

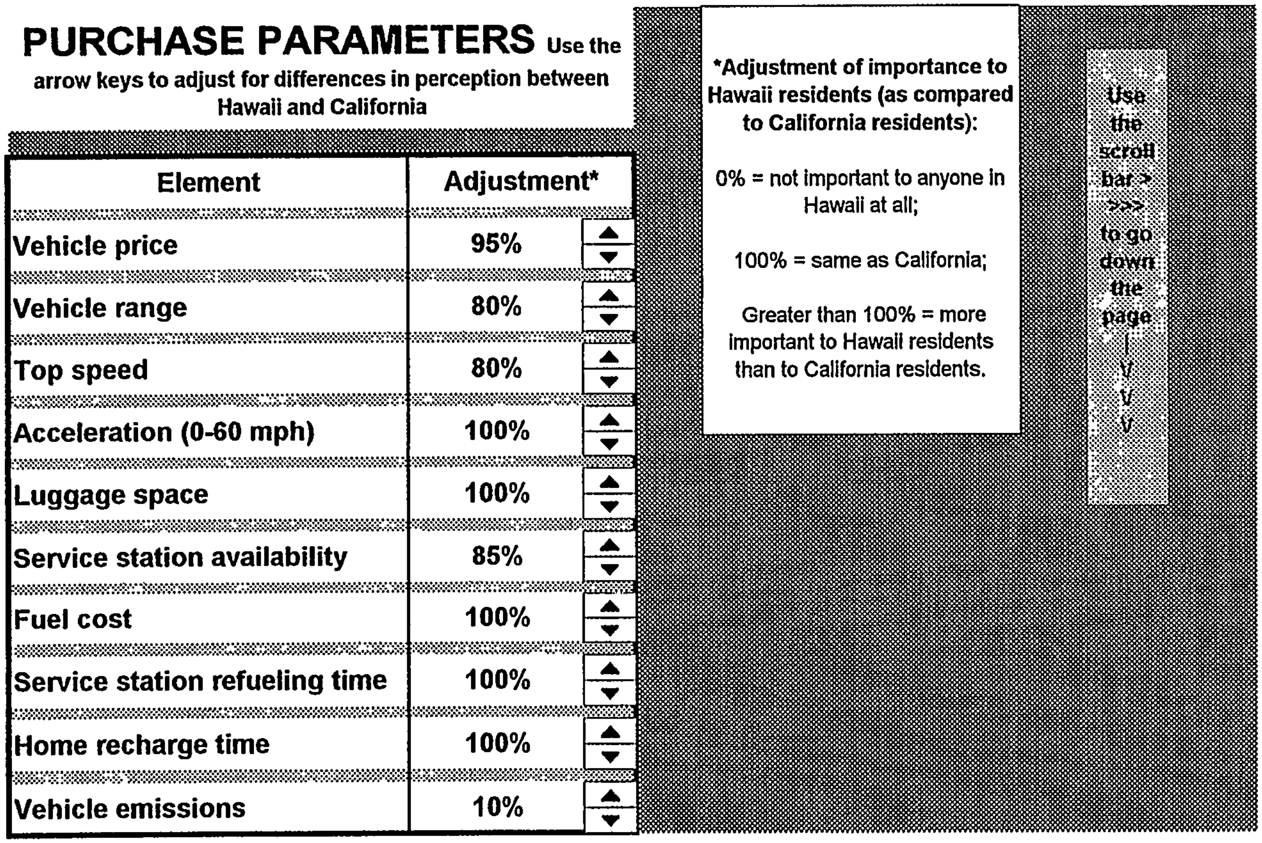
0.0%	
GEG ethanol	
from	to
0	0
0	0
0	0
0	0
0	0
0	0
0	0
0	0
0	0
0	0
0	0
0	0
0	0
0	0
0	0
0	0
0	0
0	0
0	0
0	0

Vehicle Technology and Cost



Vehicle characteristics in yellow may be changed using the arrows. When finished, click the "DONE" button.

	YEAR				
GASOLINE	1995	2000	2005	2010	2015
vehicle price	$10,000	$10,000	$10,000	$10,000	$10,000
service station refueling time (minutes)	5	5	5	5	5
ALCOHOL	1995	2000	2005	2010	2015
vehicle price	$10,500	$10,400	$10,300	$10,200	$10,100
ELECTRIC	1995	2000	2005	2010	2015
vehicle price	$30,000	$23,000	$18,000	$15,000	$14,000
range (miles)	100	150	175	200	200
top speed (% of gasoline)	78%	80%	82%	84%	86%
service station refueling time (minutes)	30	26	22	18	14
home fueling time (hours)	4.00	4.00	4.00	4.00	4.00
LPG	1995	2000	2005	2010	2015
vehicle price	$11,500	$11,100	$10,900	$10,800	$10,800
cargo space (% of gasoline)	80%	80%	80%	80%	80%



PURCHASE PARAMETERS

Use the arrow keys to adjust for differences in perception between Hawaii and California

Element	Adjustment*
Vehicle price	95%
Vehicle range	80%
Top speed	80%
Acceleration (0-60 mph)	100%
Luggage space	100%
Service station availability	85%
Fuel cost	100%
Service station refueling time	100%
Home recharge time	100%
Vehicle emissions	10%

*Adjustment of importance to Hawaii residents (as compared to California residents):

0% = not important to anyone in Hawaii at all;

100% = same as California;

Greater than 100% = more important to Hawaii residents than to California residents.

Use the scroll bar > >>> to go down the page
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	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1																	
2	Year	Vehicle Price		Vehicle Price	Vehicle Range (average miles before recharge / refuel)	Top Speed (mph)	Acceleration (0-60 mph) (seconds)	Luggage space (cubic feet)	Service station availability			Fuel cost ($/gal)	Fuel cost ($ per mile)	Service station refuel time (minutes)	Home recharge time (minutes)	Vehicle emissions	Vehicle Price - Government
3	1995	$10,000		$10,000	358	120	9	15	400			$1.52	$0.0771	5	0	1	$10,000
4	1996	$10,000		$10,000	358	120	9	15	400			$1.52	$0.0771	5	0	1	$10,000
5	1997	$10,000		$10,000	358	120	9	15	400			$1.52	$0.0771	5	0	1	$10,000
6	1998	$10,000		$10,000	358	120	9	15	400			$1.52	$0.0771	5	0	1	$10,000
7	1999	$10,000		$10,000	358	120	9	15	400			$1.52	$0.0771	5	0	1	$10,000
8	2000	$10,000		$10,000	358	120	9	15	400			$1.52	$0.0771	5	0	1	$10,000
9	2001	$10,000		$10,000	358	120	9	15	400			$1.52	$0.0771	5	0	1	$10,000
10	2002	$10,000		$10,000	358	120	9	15	400			$1.52	$0.0771	5	0	1	$10,000
11	2003	$10,000		$10,000	358	120	9	15	400			$1.52	$0.0771	5	0	1	$10,000
12	2004	$10,000		$10,000	358	120	9	15	400			$1.52	$0.0771	5	0	1	$10,000
13	2005	$10,000		$10,000	358	120	9	15	400			$1.52	$0.0771	5	0	1	$10,000
14	2006	$10,000		$10,000	358	120	9	15	400			$1.52	$0.0771	5	0	1	$10,000
15	2007	$10,000		$10,000	358	120	9	15	400			$1.52	$0.0771	5	0	1	$10,000
16	2008	$10,000		$10,000	358	120	9	15	400			$1.52	$0.0771	5	0	1	$10,000
17	2009	$10,000		$10,000	358	120	9	15	400			$1.52	$0.0771	5	0	1	$10,000
18	2010	$10,000		$10,000	358	120	9	15	400			$1.52	$0.0771	5	0	1	$10,000
19	2011	$10,000		$10,000	358	120	9	15	400			$1.52	$0.0771	5	0	1	$10,000
20	2012	$10,000		$10,000	358	120	9	15	400			$1.52	$0.0771	5	0	1	$10,000
21	2013	$10,000		$10,000	358	120	9	15	400			$1.52	$0.0771	5	0	1	$10,000
22	2014	$10,000		$10,000	358	120	9	15	400			$1.52	$0.0771	5	0	1	$10,000
23	2015	$10,000		$10,000	358	120	9	15	400			$1.52	$0.0771	5	0	1	$10,000
24	yond 20	$10,000		$10,000	358	120	9	15	400			$1.52	$0.0771	5	0	1	$10,000
25																	
26	efficien	--			0.003250	0.326200	-0.075000	0.263400	1.000000			--	-0.810000	-0.209200	-0.000760	-0.618900	
27	Hawaii	95%			80%	80%	100%	100%	85%			--	100%	100%	100%	10%	
28																	

	A	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ
1		values / utility										score elements								
2	Year	Vehicle Price - Private	Vehicle Range (average miles before recharge / refuel)	Top Speed (mph)	Acceleration (0-60 mph) (seconds)	Luggage space (cubic feet)	Service station availability	Fuel cost ($ per mile)	Service station refuel time (minutes)	Home recharge time (minutes)	Vehicle emissions	Vehicle Price - Government	Vehicle Price - Private - 0-15k	Vehicle Price - Private - 15-50k	Vehicle Price - Private - 50-75k	Vehicle Price - Private - 75+k	Vehicle Range (average miles before recharge / refuel)	Top Speed (mph)	Acceleration (0-60 mph) (seconds)	Luggage space (cubic feet)
3	1995	$10,000	358	100%	100%	100%	0.00	100%	0	0.00	100%	-0.57	-0.95	-0.57	-0.38	-0.3325	0.9295	0.26096	-0.075	0.2634
4	1996	$10,000	358	100%	100%	100%	0.00	100%	0	0.00	100%	-0.57	-0.95	-0.57	-0.38	-0.3325	0.9295	0.26096	-0.075	0.2634
5	1997	$10,000	358	100%	100%	100%	0.00	100%	0	0.00	100%	-0.57	-0.95	-0.57	-0.38	-0.3325	0.9295	0.26096	-0.075	0.2634
6	1998	$10,000	358	100%	100%	100%	0.00	100%	0	0.00	100%	-0.57	-0.95	-0.57	-0.38	-0.3325	0.9295	0.26096	-0.075	0.2634
7	1999	$10,000	358	100%	100%	100%	0.00	100%	0	0.00	100%	-0.57	-0.95	-0.57	-0.38	-0.3325	0.9295	0.26096	-0.075	0.2634
8	2000	$10,000	358	100%	100%	100%	0.00	100%	0	0.00	100%	-0.57	-0.95	-0.57	-0.38	-0.3325	0.9295	0.26096	-0.075	0.2634
9	2001	$10,000	358	100%	100%	100%	0.00	100%	0	0.00	100%	-0.57	-0.95	-0.57	-0.38	-0.3325	0.9295	0.26096	-0.075	0.2634
10	2002	$10,000	358	100%	100%	100%	0.00	100%	0	0.00	100%	-0.57	-0.95	-0.57	-0.38	-0.3325	0.9295	0.26096	-0.075	0.2634
11	2003	$10,000	358	100%	100%	100%	0.00	100%	0	0.00	100%	-0.57	-0.95	-0.57	-0.38	-0.3325	0.9295	0.26096	-0.075	0.2634
12	2004	$10,000	358	100%	100%	100%	0.00	100%	0	0.00	100%	-0.57	-0.95	-0.57	-0.38	-0.3325	0.9295	0.26096	-0.075	0.2634
13	2005	$10,000	358	100%	100%	100%	0.00	100%	0	0.00	100%	-0.57	-0.95	-0.57	-0.38	-0.3325	0.9295	0.26096	-0.075	0.2634
14	2006	$10,000	358	100%	100%	100%	0.00	100%	0	0.00	100%	-0.57	-0.95	-0.57	-0.38	-0.3325	0.9295	0.26096	-0.075	0.2634
15	2007	$10,000	358	100%	100%	100%	0.00	100%	0	0.00	100%	-0.57	-0.95	-0.57	-0.38	-0.3325	0.9295	0.26096	-0.075	0.2634
16	2008	$10,000	358	100%	100%	100%	0.00	100%	0	0.00	100%	-0.57	-0.95	-0.57	-0.38	-0.3325	0.9295	0.26096	-0.075	0.2634
17	2009	$10,000	358	100%	100%	100%	0.00	100%	0	0.00	100%	-0.57	-0.95	-0.57	-0.38	-0.3325	0.9295	0.26096	-0.075	0.2634
18	2010	$10,000	358	100%	100%	100%	0.00	100%	0	0.00	100%	-0.57	-0.95	-0.57	-0.38	-0.3325	0.9295	0.26096	-0.075	0.2634
19	2011	$10,000	358	100%	100%	100%	0.00	100%	0	0.00	100%	-0.57	-0.95	-0.57	-0.38	-0.3325	0.9295	0.26096	-0.075	0.2634
20	2012	$10,000	358	100%	100%	100%	0.00	100%	0	0.00	100%	-0.57	-0.95	-0.57	-0.38	-0.3325	0.9295	0.26096	-0.075	0.2634
21	2013	$10,000	358	100%	100%	100%	0.00	100%	0	0.00	100%	-0.57	-0.95	-0.57	-0.38	-0.3325	0.9295	0.26096	-0.075	0.2634
22	2014	$10,000	358	100%	100%	100%	0.00	100%	0	0.00	100%	-0.57	-0.95	-0.57	-0.38	-0.3325	0.9295	0.26096	-0.075	0.2634
23	2015	$10,000	358	100%	100%	100%	0.00	100%	0	0.00	100%	-0.57	-0.95	-0.57	-0.38	-0.3325	0.9295	0.26096	-0.075	0.2634
24	yond 20	$10,000	358	100%	100%	100%	0.00	100%	0	0.00	100%	-0.57	-0.95	-0.57	-0.38	-0.3325	0.9295	0.26096	-0.075	0.2634
25																				
26	efficien																			
27	Hawaii																			
28																				

	A	AK	AL	AM	AN	AO	AP	AQ	AR	AS	AT	AU	AV	AW	AX
1							final sums					final scores			
2	Year	Service station availability	Fuel cost ($ per mile)	Service station refuel time (minutes)	Home recharge time (minutes)	Vehicle emissions	Government	Private - 0-15k	Private - 15 50k	Private - 50-75k	Private - 75+k	Government	Private - 0-15k	Private - 15-50k	Private - 50-75k
3	1995	0	-0.81	0	0	-0.06189	-0.06303	-0.44303	-0.06303	0.12697	0.17447	0.938915306	0.642087944	0.938915306	1.135382956
4	1996	0	-0.81	0	0	-0.06189	-0.06303	-0.44303	-0.06303	0.12697	0.17447	0.938915306	0.642087944	0.938915306	1.135382956
5	1997	0	-0.81	0	0	-0.06189	-0.06303	-0.44303	-0.06303	0.12697	0.17447	0.938915306	0.642087944	0.938915306	1.135382956
6	1998	0	-0.81	0	0	-0.06189	-0.06303	-0.44303	-0.06303	0.12697	0.17447	0.938915306	0.642087944	0.938915306	1.135382956
7	1999	0	-0.81	0	0	-0.06189	-0.06303	-0.44303	-0.06303	0.12697	0.17447	0.938915306	0.642087944	0.938915306	1.135382956
8	2000	0	-0.81	0	0	-0.06189	-0.06303	-0.44303	-0.06303	0.12697	0.17447	0.938915306	0.642087944	0.938915306	1.135382956
9	2001	0	-0.81	0	0	-0.06189	-0.06303	-0.44303	-0.06303	0.12697	0.17447	0.938915306	0.642087944	0.938915306	1.135382956
10	2002	0	-0.81	0	0	-0.06189	-0.06303	-0.44303	-0.06303	0.12697	0.17447	0.938915306	0.642087944	0.938915306	1.135382956
11	2003	0	-0.81	0	0	-0.06189	-0.06303	-0.44303	-0.06303	0.12697	0.17447	0.938915306	0.642087944	0.938915306	1.135382956
12	2004	0	-0.81	0	0	-0.06189	-0.06303	-0.44303	-0.06303	0.12697	0.17447	0.938915306	0.642087944	0.938915306	1.135382956
13	2005	0	-0.81	0	0	-0.06189	-0.06303	-0.44303	-0.06303	0.12697	0.17447	0.938915306	0.642087944	0.938915306	1.135382956
14	2006	0	-0.81	0	0	-0.06189	-0.06303	-0.44303	-0.06303	0.12697	0.17447	0.938915306	0.642087944	0.938915306	1.135382956
15	2007	0	-0.81	0	0	-0.06189	-0.06303	-0.44303	-0.06303	0.12697	0.17447	0.938915306	0.642087944	0.938915306	1.135382956
16	2008	0	-0.81	0	0	-0.06189	-0.06303	-0.44303	-0.06303	0.12697	0.17447	0.938915306	0.642087944	0.938915306	1.135382956
17	2009	0	-0.81	0	0	-0.06189	-0.06303	-0.44303	-0.06303	0.12697	0.17447	0.938915306	0.642087944	0.938915306	1.135382956
18	2010	0	-0.81	0	0	-0.06189	-0.06303	-0.44303	-0.06303	0.12697	0.17447	0.938915306	0.642087944	0.938915306	1.135382956
19	2011	0	-0.81	0	0	-0.06189	-0.06303	-0.44303	-0.06303	0.12697	0.17447	0.938915306	0.642087944	0.938915306	1.135382956
20	2012	0	-0.81	0	0	-0.06189	-0.06303	-0.44303	-0.06303	0.12697	0.17447	0.938915306	0.642087944	0.938915306	1.135382956
21	2013	0	-0.81	0	0	-0.06189	-0.06303	-0.44303	-0.06303	0.12697	0.17447	0.938915306	0.642087944	0.938915306	1.135382956
22	2014	0	-0.81	0	0	-0.06189	-0.06303	-0.44303	-0.06303	0.12697	0.17447	0.938915306	0.642087944	0.938915306	1.135382956
23	2015	0	-0.81	0	0	-0.06189	-0.06303	-0.44303	-0.06303	0.12697	0.17447	0.938915306	0.642087944	0.938915306	1.135382956
24	yond.20	0	-0.81	0	0	-0.06189	-0.06303	-0.44303	-0.06303	0.12697	0.17447	0.938915306	0.642087944	0.938915306	1.135382956
25															
26	efficien														
27	Hawaii														
28															

	A	AY	AZ	BA	BB	BC	BD
1		Additional costs	Additional costs-private				
2	Year	Private - 75+k	Per new Vehicle	Per annual fuel	Per new Vehicle	Per annual fuel	Fuel use per vehicle per year (GEG)
3	1995	1.190615023	$0	$0	$0	$0	431.85
4	1996	1.190615023	$0	$0	$0	$0	421.09
5	1997	1.190615023	$0	$0	$0	$0	416.98
6	1998	1.190615023	$0	$0	$0	$0	412.88
7	1999	1.190615023	$0	$0	$0	$0	408.77
8	2000	1.190615023	$0	$0	$0	$0	402.84
9	2001	1.190615023	$0	$0	$0	$0	396.90
10	2002	1.190615023	$0	$0	$0	$0	390.97
11	2003	1.190615023	$0	$0	$0	$0	385.03
12	2004	1.190615023	$0	$0	$0	$0	379.10
13	2005	1.190615023	$0	$0	$0	$0	376.08
14	2006	1.190615023	$0	$0	$0	$0	373.07
15	2007	1.190615023	$0	$0	$0	$0	370.05
16	2008	1.190615023	$0	$0	$0	$0	367.03
17	2009	1.190615023	$0	$0	$0	$0	364.02
18	2010	1.190615023	$0	$0	$0	$0	361.00
19	2011	1.190615023	$0	$0	$0	$0	357.99
20	2012	1.190615023	$0	$0	$0	$0	354.97
21	2013	1.190615023	$0	$0	$0	$0	351.96
22	2014	1.190615023	$0	$0	$0	$0	348.94
23	2015	1.190615023	$0	$0	$0	$0	348.94
24	yond 20	1.190615023	$0	$0	$0	$0	348.94
25							
26	efficien						
27	Hawaii						
28							

	A	B	C	D	E	F	G	H	I
30	MPG (gasoline	MPG (actual)			gallons fuel cap	fuel dispenser rate (gpm)		<15k	-0.000100
31	19.77	19.77			13	8		15-45k	-0.000060
32								45-60k	-0.000040
33	*If can charge at home, use (1-(time%)) x -.3621							>60k	-0.000035
34	**If no dual fuel, use (LN(ssa%)) x 0.3901								
35									
36	8805	(from DOT est. VMT)							
37	miles per vehicle per year								
38									
39		vehicles	stations	vehicles per station	stations per vehicle				
40	gasoline	870,924	400	2,177	0.000				
41	alcohol	15	1	15	0.068				
42	electric	16	2	8	0.122				
43	LPG	123	23	5	0.186				
44	used in estimating # of stations			2,000	0.001				

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1	alcohol			Voluntary individual purchases					Voluntary fleet purchases					Voluntary government purchases				
2	Year	% of car models avail. in alcohol versions	% of truck models avail. in alcohol versions	Max. potential alcohol vehicle buyers	alcohol car adoptions	Annual alcohol car sales	alcohol truck adoptions	Annual alcohol truck sales	Max. potential alcohol vehicle buyers	alcohol car adoptions	Annual alcohol car sales	alcohol truck adoptions	Annual alcohol truck sales	Max. potential alcohol vehicle buyers	alcohol car adoptions	Annual alcohol car sales	alcohol truck adoptions	Annual alcohol truck sales
3	1994	9%	9%	26%	0	0	0	0	26%	0	0	0	0	26%	0	0	0	0
4	1995	9%	9%	26%	1	1	0	0	26%	2	1	0	0	26%	0	0	0	0
5	1996	9%	9%	26%	5	4	0	0	26%	8	6	1	1	26%	0	0	0	0
6	1997	9%	9%	26%	15	13	0	0	26%	25	21	4	3	26%	0	0	1	0
7	1998	9%	9%	26%	35	37	1	1	26%	60	62	9	9	26%	1	1	1	1
8	1999	9%	9%	25%	69	89	1	2	26%	116	150	17	22	26%	1	2	2	3
9	2000	9%	9%	25%	108	180	2	3	26%	182	303	26	44	25%	2	3	4	7
10	2001	9%	9%	25%	137	309	2	5	26%	231	519	33	75	25%	2	5	5	11
11	2002	9%	9%	25%	140	457	2	8	26%	235	767	34	111	25%	2	8	5	17
12	2003	9%	9%	25%	114	592	2	10	25%	191	992	28	144	25%	2	11	4	21
13	2004	9%	9%	25%	75	700	1	12	25%	126	1,173	18	170	25%	1	12	3	25
14	2005	9%	9%	26%	41	791	1	14	26%	68	1,324	10	192	26%	1	14	1	29
15	2006	9%	9%	25%	17	827	0	15	26%	29	1,383	4	201	26%	0	15	1	30
16	2007	9%	9%	25%	6	854	0	15	26%	10	1,428	1	207	26%	0	15	0	31
17	2008	9%	9%	25%	2	867	0	15	25%	3	1,449	0	210	25%	0	15	0	31
18	2009	9%	9%	25%	0	883	0	15	25%	1	1,475	0	214	25%	0	16	0	32
19	2010	9%	9%	25%	0	889	0	16	25%	1	1,482	0	215	25%	0	16	0	32
20	2011	9%	9%	25%	0	913	0	16	25%	1	1,524	0	221	25%	0	16	0	33
21	2012	9%	9%	25%	0	931	0	16	25%	1	1,554	0	226	25%	0	17	0	34
22	2013	9%	9%	25%	0	950	0	17	25%	1	1,585	0	230	25%	0	17	0	34
23	2014	9%	9%	25%	0	969	0	17	25%	1	1,616	0	235	25%	0	17	0	35
24	2015	9%	9%	25%	0	984	0	17	25%	1	1,642	0	238	25%	0	17	0	36

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1	electric			Voluntary individual purchases					Voluntary fleet purchases					Voluntary government purchases				
2	Year	% of car models avail. in electric versions	% of truck models avail. in electric versions	Max. potential electric vehicle buyers	electric car adoptions	Annual electric car sales	electric truck adoptions	Annual electric truck sales	Max. potential electric vehicle buyers	electric car adoptions	Annual electric car sales	electric truck adoptions	Annual electric truck sales	Max. potential electric vehicle buyers	electric car adoptions	Annual electric car sales	electric truck adoptions	Annual electric truck sales
3	1994	5%	5%	9%	0	0	0	0	8%	0	0	0	0	7%	0	0	0	0
4	1995	5%	5%	9%	0	0	0	0	8%	0	0	0	0	7%	0	0	0	0
5	1996	5%	5%	10%	1	1	0	0	9%	2	1	0	0	8%	0	0	0	0
6	1997	5%	5%	11%	3	3	0	0	10%	5	4	1	1	9%	0	0	0	0
7	1998	5%	5%	12%	9	10	0	0	11%	13	14	2	2	10%	0	0	0	0
8	1999	5%	5%	13%	20	25	0	0	12%	29	37	4	5	11%	0	0	1	1
9	2000	5%	5%	14%	33	55	1	1	13%	50	83	7	12	12%	0	1	1	2
10	2001	5%	5%	15%	44	100	1	2	13%	68	152	10	22	12%	1	1	1	3
11	2002	5%	5%	15%	48	156	1	3	14%	73	239	11	35	13%	1	2	1	5
12	2003	5%	5%	16%	41	214	1	4	15%	64	332	9	48	14%	1	3	1	7
13	2004	5%	5%	17%	28	260	0	5	16%	44	406	6	59	15%	0	4	1	8
14	2005	5%	5%	17%	15	299	0	5	17%	24	470	4	68	16%	0	5	0	10
15	2006	5%	5%	18%	7	329	0	6	17%	11	520	2	75	16%	0	5	0	11
16	2007	5%	5%	18%	2	346	0	6	18%	4	548	1	79	17%	0	6	0	11
17	2008	5%	5%	19%	1	368	0	6	18%	1	586	0	85	18%	0	6	0	12
18	2009	5%	5%	20%	0	386	0	7	19%	0	617	0	89	18%	0	6	0	13
19	2010	5%	5%	21%	0	410	0	7	20%	0	658	0	96	19%	0	7	0	14
20	2011	5%	5%	20%	0	413	0	7	20%	0	660	0	96	20%	0	7	0	14
21	2012	5%	5%	21%	0	427	0	7	20%	0	684	0	99	20%	0	7	0	15
22	2013	5%	5%	21%	0	442	0	8	20%	0	708	0	103	20%	0	8	0	15
23	2014	5%	5%	21%	0	457	0	8	21%	0	734	0	107	21%	0	8	0	16
24	2015	5%	5%	21%	0	475	0	8	21%	0	764	0	111	21%	0	8	0	17

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1	LPG			Voluntary individual purchases					Voluntary fleet purchases					Voluntary government purchases				
2	Year	% of car models avail. in LPG versions	% of truck models avail. in LPG versions	Max. potential LPG vehicle buyers	LPG car adoptions	Annual LPG car sales	LPG truck adoptions	Annual LPG truck sales	Max. potential LPG vehicle buyers	LPG car adoptions	Annual LPG car sales	LPG truck adoptions	Annual LPG truck sales	Max. potential LPG vehicle buyers	LPG car adoptions	Annual LPG car sales	LPG truck adoptions	Annual LPG truck sales
3	1994	5%	10%	22%	0	0	0	0	22%	0	0	0	0	22%	0	0	0	0
4	1995	5%	10%	22%	1	0	0	0	22%	1	1	0	0	22%	0	0	0	0
5	1996	5%	10%	22%	2	2	0	0	22%	4	3	1	1	23%	0	0	0	0
6	1997	5%	10%	22%	7	6	0	0	22%	12	10	3	3	23%	0	0	1	0
7	1998	5%	10%	22%	17	18	1	1	22%	28	30	8	9	23%	0	0	1	1
8	1999	5%	10%	22%	33	43	1	2	22%	55	72	16	21	23%	1	1	2	3
9	2000	5%	10%	22%	53	87	2	3	22%	87	145	25	42	23%	1	2	4	6
10	2001	5%	10%	22%	67	150	2	5	22%	111	250	32	73	23%	1	3	5	11
11	2002	5%	10%	22%	68	223	2	8	22%	113	371	33	108	23%	1	4	5	16
12	2003	5%	10%	22%	56	292	2	10	22%	93	485	27	141	23%	1	5	4	21
13	2004	5%	10%	22%	37	346	1	12	22%	62	576	18	167	23%	1	6	3	25
14	2005	5%	10%	22%	19	376	1	13	22%	32	623	9	181	22%	0	7	1	28
15	2006	5%	10%	22%	8	396	0	14	22%	14	657	4	191	22%	0	7	1	29
16	2007	5%	10%	22%	3	409	0	14	22%	5	680	1	197	22%	0	7	0	30
17	2008	5%	10%	22%	1	418	0	15	22%	1	694	0	201	22%	0	7	0	30
18	2009	5%	10%	22%	0	426	0	15	22%	0	707	0	205	22%	0	8	0	31
19	2010	5%	10%	22%	0	434	0	15	22%	0	719	0	209	22%	0	8	0	31
20	2011	5%	10%	22%	0	446	0	16	22%	0	740	0	215	22%	0	8	0	32
21	2012	5%	10%	22%	0	455	0	16	22%	0	755	0	219	22%	0	8	0	33
22	2013	5%	10%	22%	0	465	0	16	22%	0	771	0	224	22%	0	8	0	33
23	2014	5%	10%	22%	0	474	0	17	22%	0	786	0	228	22%	0	8	0	34
24	2015	5%	10%	22%	0	481	0	17	22%	0	798	0	232	22%	0	8	0	35

1992 Statewide Fleet Population Estimates: 8500 lb.. GVW and under

Federal	cars	643	(Note: Tactical military vehicles not included)
	trucks	1,440	

Source: *Hawaii Federal GSA and the First Interim Report of the Federal Fleet Conversion Task Force (August, 1993)*

		Statewide	Oahu		Summary of Registered Vehicles Data:					
					Oahu	Kauai	Maui	Hawaii		
State	cars	1,468	865							
	trucks (0-10,000)	1,685	1,065	pass veh	1,798	0	0	0	0.82	
	other (bus & truck)	321	165	pass trucks	81	0	0	0	20.80	ratio of total trucks 0-10,0
	total	3,474	2,095	other	2,301	0	0	0		
Source:	*Department of Accounting and General Services, ru*			total	4,180	0	0	0		
Note:	DAGS data used									

		Statewide	Oahu	% centrally fueled		Oahu	Kauai	Maui	Hawaii	TOTAL	
County Gov	cars	1,507	800	50%	pass veh	980	218	481	167	1,846	
	light trucks	4,514	1,082	50%	pass trucks	52	67	56	42	217	
	other	760	2,617		other	3,467	131	387	733	4,718	(Other = (county+fire+poli
Source:	*Summary of Registered Vehicles, Run Date 9/5/92,*				total	4,499	416	924	942	6,781	
	trucks adjusted by ratio of light trucks to pass trucks from state										

					Oahu	% on Oahu	% in centrally fueled fleets		
Private	cars	19,232	(Note: Statewide estimate, fleets of al	cars	13,362	69%	43%	270	# of fleets (sc
Fleets	trucks	33,516	no central refueling capability restricti	trucks	24,856	74%	43%	116	# of locations
									(from DOH U

Source: *Private fleet size estimates from Automotive Fleet Fact Book, 1992, Bobit Publishing Company*

95% of trucks in class I-V assumed to be under 8500 lb. based on USGSA and MVMA data

			Oahu
Rental Car	cars	38,491	26,742
	trucks	0	0

Source: *Figures for 1992; Hawaii Automobile Dealers Association Yearbook, 1994*

Private Indivi	cars	69,832
(purch new)	trucks	2,450

Source: *Figures for 1992; Hawaii Automobile Dealers Association Yearbook, 1994; retail sales - fleet & government sales above*

Fleet Turnover Rate

Federal	cars	20%
	trucks	17%

Notes: Average vehicle life assumed to be 9 years.

Source: City and County of Honolulu (90%) and DAGS (93%)

Source: *Hawaii GSA*

State	cars	13%
	trucks	13%

Source: *Assumed equal to City and County of Honolulu rate*

Local Gov	cars	13%
	trucks	13%

Source: *City and County of Honolulu Dept. of Public Works, Dept. of Parks and Recreation, and Board of Water*

Private fleet	cars	40%
	trucks	20%

Source: *Assumed equal to national rate (Reference 21)*

Rental Car	cars	100%
	trucks	100%

Source: *Acurex Estimate*

Private Indiv	cars	40%
	trucks	20%

Source: *Calculated based on new vehicle registrations and the above fleet turnover rates*

Fleet Growth Rate

		User enterec	Default rate:
Federal	cars	2.02%	2.02%
	trucks	2.02%	2.02%

		User enterec	Default rate:
State	cars	2.02%	2.02%
	trucks	2.02%	2.02%

		User enterec	Default rate:
Local Gov	cars	2.02%	2.02%
	trucks	2.02%	2.02%

		User enterec	Default rate:
Private fleet	cars	2.02%	2.02%
	trucks	2.02%	2.02%

		User enterec	Default rate:
Rental Cars	cars	2.02%	2.02%
	trucks	2.02%	2.02%

Percentage of AFVs leaving federal government flee	Default:	90%
assumed to be resold and retained in the islands:	User Entered:	90%

Age of vehicle (yrs) at sale: 5
Average vehicle life (yrs): 9

Federal

Federal Fleet Acquisition of Light Duty Alternative Fuel Vehicles

Year	autos	light trucks	new autos	ew light truck	EPACT %	AFV cars	AFV trucks	AFV cars	AFV trucks	Alcohol		EV		LPG	
						(new)	(new)	cumulative	cumulative	new cars	new trucks	new cars	new trucks	new cars	new trucks
1992	643	1,440													
1993	656	1,469	131	250	17%	5	0			5	0	0	0	0	0
1994	669	1,499	134	255	24%	6	0			6	0	0	0	0	0
1995	683	1,529	137	260	32%	7	0			4	0	1	0	2	0
1996	696	1,560	139	265	25%	35	66			21	31	4	5	10	30
1997	710	1,591	142	270	33%	47	89			28	41	5	8	14	40
1998	725	1,623	145	276	50%	72	138			43	63	9	13	21	62
1999	739	1,656	148	281	75%	111	211			65	96	15	22	32	94
2000	754	1,689	151	287	75%	113	215			65	96	16	24	32	95
2001	769	1,723	154	293	75%	115	220			65	97	18	26	32	96
2002	785	1,758	157	299	75%	118	224			66	98	19	28	33	98
2003	801	1,793	160	305	75%	120	229			67	99	20	30	33	99
2004	817	1,830	163	311	90%	147	280			81	120	26	39	40	121
2005	833	1,866	167	317	90%	150	286			83	124	28	41	40	120
2006	850	1,904	170	324	90%	153	291			84	126	29	44	40	121
2007	867	1,942	173	330	90%	156	297			84	127	31	47	41	123
2008	885	1,982	177	337	90%	159	303			85	129	33	50	41	125
2009	903	2,021	181	344	90%	162	309			86	130	35	53	42	126
2010	921	2,062	184	351	90%	166	316			87	132	37	56	42	128
2011	939	2,104	188	358	90%	169	322			88	134	38	58	43	130
2012	958	2,146	192	365	90%	172	328			90	136	39	60	44	132
2013	978	2,189	196	372	90%	176	335			91	138	41	62	44	135
2014	997	2,234	199	380	90%	180	342			92	141	42	64	45	137
2015	1,017	2,279	203	387	90%	183	349			94	143	44	67	46	139
2016	1,038	2,324	208	395	90%	187	356			96	146	45	68	47	142

Cumulative AFVs in fe

	cumulative
Alcohol	EV
5	0
11	0
15	1
67	9
137	22
238	44
392	81
549	121
659	156
754	190
814	219
855	247
901	275
948	305
995	336
1,043	368
1,059	390
1,070	415
1,082	437
1,096	459
1,112	479
1,129	497
1,147	514
1,167	531

Percentage c																	NEW
assumed to t		Federal fleet AFVs										non-AFVs					vehicles
Federal	deral fleet	Used vehicles sold to local purchasers			Vehicles permanently retired			net additional AFVs to gen. public				Non-AFVs Sold to local purchasers			Non-AFVs Permanently retired		
Year		annually			annually			annually				annually			annually		
1992	LPG	Alcohol	EV	LPG	Alcohol	EV	LPG	Alcohol	EV	LPG	total			LDVs		LDVs	
1993	0	0	0	0	0	0	0	0	0	0	0			382		212	381
1994	0	0	0	0	0	0	0	0	0	0	0			388		216	389
1995	2	0	0	0	0	0	0	0	0	0	0			395		219	396
1996	42	0	0	0	0	0	0	0	0	0	0			385		214	404
1997	96	0	0	0	0	0	0	0	0	0	0			368		205	413
1998	178	5	0	0	0	0	0	5	0	0	5			340		189	421
1999	304	5	0	0	0	0	0	5	0	0	5			291		162	429
2000	429	4	1	2	0	0	0	4	1	2	6			242		135	438
2001	517	47	8	36	0	0	0	47	8	36	91			209		116	447
2002	594	62	12	48	5	0	0	58	12	48	118			181		100	456
2003	644	95	20	74	5	0	0	90	20	74	184			165		92	465
2004	679	144	33	113	4	1	2	140	32	111	284			156		87	474
2005	712	145	37	114	47	8	36	98	29	78	205			146		81	484
2006	745	146	39	116	62	12	48	84	28	67	179			136		76	494
2007	778	148	42	118	95	20	74	52	23	43	118			126		70	504
2008	811	149	45	119	144	33	113	5	12	6	24			116		64	514
2009	818	181	59	145	145	37	114	36	22	31	89			118		66	524
2010	829	186	62	144	146	39	116	40	23	28	90			121		67	535
2011	840	189	66	145	148	42	118	41	24	28	92			123		68	546
2012	852	191	70	147	149	45	119	41	25	28	94			125		70	557
2013	865	193	74	149	181	59	145	12	16	4	32			128		71	568
2014	879	195	79	151	186	62	144	8	17	8	33			131		73	579
2015	894	196	84	153	189	66	145	8	18	7	33			133		74	591
2016	910	200	87	156	191	70	147	9	17	8	34			136		76	603

Percentage c NEW
assumed to t AFVs
Federal

Year		Additional cost for AFV purchases			Additional cost for fuel			Total Additiona	Total	Total	0	
1992		Alcohol	EV	LPG	Alcohol	EV	LPG	All	voluntary	EPACT	0	
1993	5							Fuels	cost	Cost	0	
1994	6								0	0	0	
1995	7	$2,147	$13,298	$3,085	$4,798	($366)	$1,000	$21,815	$6,422	$24,695		$0
1996	101	$25,036	$163,685	$57,007	$20,634	($5,084)	$20,008	$256,250	$6,448	$259,089		$0
1997	136	$31,940	$223,072	$72,017	$41,466	($11,934)	$45,044	$369,666	$7,004	$372,478		$0
1998	210	$46,842	$346,389	$103,969	$71,353	($23,363)	$82,957	$581,305	$7,246	$584,239		$0
1999	322	$67,226	$527,903	$147,858	$116,393	($42,247)	$139,799	$889,706	$9,165	$892,789		$0
2000	329	$64,397	$528,634	$139,545	$160,560	($62,189)	$194,372	$960,922	$15,306	$964,150		$0
2001	335	$61,818	$524,766	$136,450	$190,061	($78,959)	$231,091	$1,003,409	$24,104	$1,009,441		$0
2002	342	$59,152	$517,183	$133,174	$214,166	($94,759)	$261,450	$1,031,213	$34,317	$1,040,846		$0
2003	349	$56,398	$505,369	$129,718	$227,662	($107,375)	$279,091	$1,034,464	$44,025	$1,049,416		$0
2004	427	$64,272	$586,509	$151,294	$235,386	($119,506)	$290,004	$1,143,686	$51,604	$1,166,391		$0
2005	436	$62,135	$552,078	$143,504	$213,046	($132,155)	$301,496	$1,077,969	$54,794	$1,106,242		$0
2006	444	$58,654	$542,241	$142,205	$222,317	($145,156)	$312,884	$1,074,492	$58,207	$1,109,681		$0
2007	453	$55,065	$529,092	$140,792	$231,568	($158,518)	$324,166	$1,067,100	$59,889	$1,109,048		$0
2008	462	$51,368	$512,262	$139,261	$240,796	($172,249)	$335,335	$1,055,405	$60,316	$1,103,942		$0
2009	472	$47,566	$491,322	$137,611	$242,332	($181,314)	$335,394	$1,025,346	$59,866	$1,081,653		$0
2010	481	$43,661	$465,819	$135,840	$242,865	($190,936)	$336,823	$990,411	$58,770	$1,054,256		$0
2011	491	$39,960	$461,611	$138,240	$243,654	($199,795)	$338,524	$982,235	$58,972	$1,053,429		$0
2012	501	$36,116	$456,811	$140,664	$244,713	($207,848)	$340,516	$974,856	$59,153	$1,053,198		$0
2013	511	$32,128	$451,320	$143,115	$246,055	($215,039)	$342,817	$968,268	$59,347	$1,053,541		$0
2014	521	$27,993	$445,153	$145,588	$247,692	($221,321)	$345,445	$962,557	$59,570	$1,054,530		$0
2015	532	$23,690	$440,897	$147,707	$251,772	($228,915)	$351,272	$962,734	$60,058	$1,062,021		$0
2016	542	$24,167	$449,782	$150,684	$256,089	($236,161)	$357,383	$977,778	$60,608	$1,084,445		$0

Percentage of AFVs leaving state government fleets Default: 90%
assumed to be resold and retained in the islands: User Entered: 90%

Age of vehicle (yrs) at sale: 8
Average vehicle life (yrs): 9

State						State	Fleet Acquisition of Light Duty Alternative Fuel Vehicles										Cumulative AFVs in s	
Year	autos	light trucks	new autos	ew light truck	EPACT	State fleet	AFV cars	AFV trucks	AFV cars	AFV trucks	Alcohol		EV		LPG		cumulative	
1992	1,468	1,685			%	mandate	(new)	(new)	cumulative	cumulative	cars	trucks	cars	trucks	cars	trucks	Alcohol	EV
1993	1,498	1,719	187	215	0%	0%	2	0			2	0	0	0	0	0	2	0
1994	1,528	1,754	191	219	0%	0%	0	0			0	0	0	0	0	0	2	0
1995	1,559	1,789	195	224	0%	0%	0	0			0	0	0	0	0	0	2	0
1996	1,590	1,825	199	228	10%	0%	3	2			2	1	0	0	1	1	4	0
1997	1,622	1,862	203	233	15%	0%	5	3			3	1	1	0	1	1	8	1
1998	1,655	1,899	207	237	25%	25%	52	59			31	27	6	6	15	27	66	13
1999	1,688	1,938	211	242	50%	25%	53	61			31	27	7	6	15	27	124	27
2000	1,722	1,977	215	247	75%	25%	54	62			31	28	8	7	15	27	182	41
2001	1,757	2,016	220	252	75%	25%	55	63			31	28	8	7	15	28	239	57
2002	1,792	2,057	224	257	75%	25%	56	64			31	28	9	8	16	28	298	74
2003	1,828	2,099	229	262	75%	25%	57	66			32	28	10	9	16	28	359	93
2004	1,865	2,141	233	268	90%	25%	58	67			32	29	10	9	16	29	416	112
2005	1,903	2,184	238	273	90%	25%	59	68			33	30	11	10	16	29	475	132
2006	1,941	2,228	243	278	90%	25%	61	70			33	30	12	11	16	29	480	142
2007	1,980	2,273	248	284	90%	25%	62	71			33	30	12	11	16	29	486	152
2008	2,020	2,319	253	290	90%	25%	63	72			34	31	13	12	16	30	492	162
2009	2,061	2,365	258	296	90%	25%	64	74			34	31	14	13	17	30	498	173
2010	2,102	2,413	263	302	90%	25%	66	75			34	31	15	13	17	31	504	184
2011	2,145	2,462	268	308	90%	25%	67	77			35	32	15	14	17	31	511	195
2012	2,188	2,511	273	314	90%	25%	68	78			36	33	16	14	17	32	519	205
2013	2,232	2,562	279	320	90%	25%	70	80			36	33	16	15	18	32	525	215
2014	2,277	2,614	285	327	90%	25%	71	82			37	34	17	15	18	33	532	225
2015	2,323	2,666	290	333	90%	25%	73	83			37	34	17	16	18	33	540	234
2016	2,370	2,720	296	340	90%	25%	74	85			38	35	18	16	18	34	548	243

Percentage c																		NEW
assumed to t		State fleet AFVs											non-AFVs					State fleet vehicles
State	tate fleet	Used vehicles sold to local purchasers			Vehicles permanently retired			net additional AFVs to gen. public					Non-AFVs Sold to local purchasers			Non-AFVs Permanently retired		
Year		annually			annually				annually			non-AFVs	annually			annually		
1992	LPG	Alcohol	EV	LPG	Alcohol	EV	LPG	Alcohol	EV	LPG	total	sold			LDVs		LDVs	
1993	0	0	0	0	0	0	0	0	0	0	0	0			362		321	402
1994	0	0	0	0	0	0	0	0	0	0	0	0			369		328	410
1995	0	0	0	0	0	0	0	0	0	0	0	0			376		335	418
1996	2	0	0	0	0	0	0	0	0	0	0	0			383		341	427
1997	5	0	0	0	0	0	0	0	0	0	0	0			390		347	435
1998	46	0	0	0	0	0	0	0	0	0	0	0			386		343	444
1999	88	0	0	0	0	0	0	0	0	0	0	0			381		339	453
2000	130	0	0	0	0	0	0	0	0	0	0	0			376		335	462
2001	173	2	0	0	0	0	0	2	0	0	2	0			372		330	472
2002	217	0	0	0	2	0	0	0	0	0	0	0			367		326	481
2003	261	0	0	0	0	0	0	0	0	0	0	0			362		321	491
2004	304	2	0	2	0	0	0	2	0	2	4	0			357		317	501
2005	346	4	1	3	2	0	2	1	0	1	3	0			353		313	511
2006	349	52	11	37	4	1	3	48	10	35	93	0			360		320	521
2007	353	52	12	38	52	11	37	0	1	0	2	0			367		326	532
2008	357	53	13	38	52	12	38	0	1	0	2	0			374		333	542
2009	360	53	14	39	53	13	38	1	1	1	2	0			382		339	553
2010	364	54	15	39	53	14	39	1	1	1	2	0			390		346	564
2011	368	54	16	40	54	15	39	1	1	1	2	0			397		353	576
2012	372	55	18	40	54	16	40	0	1	1	2	0			405		360	587
2013	377	56	19	40	55	18	40	2	1	0	3	0			414		368	599
2014	383	57	20	40	56	19	40	1	1	1	2	0			422		375	611
2015	388	58	21	41	57	20	40	1	1	1	2	0			430		383	624
2016	395	58	22	41	58	21	41	1	1	1	2	0			439		390	636

Percentage cNEW
assumed to lState AFVs

State Year		Additional cost for AFV purchases Alcohol	 EV	 LPG	Additional cost for fuel Alcohol	 EV	 LPG	Total Additiona All Fuels	Total voluntary cost 0	Total EPACT Cost 0	Total State-Imposed Costs	To be used in cost chart
1992												
1993	2											
1994	0											
1995	0	$6	$36	$0	$490	($1)	$4	$529	$676	$0	$0	$0
1996	5	$1,322	$8,644	$0	$1,251	($251)	$848	$10,493	$829	$10,081	$0	$0
1997	8	$2,016	$14,078	$11	$2,498	($684)	$2,154	$18,058	$1,403	$17,707	$0	$0
1998	111	$25,396	$188,608	$2,244	$19,719	($6,964)	$21,380	$224,986	$2,974	$38,345	$218,880	$186,641
1999	113	$24,397	$191,578	$3,304	$36,705	($13,832)	$40,455	$258,209	$6,440	$89,008	$251,148	$169,201
2000	116	$23,364	$191,795	$45,546	$53,200	($21,213)	$59,106	$328,434	$12,586	$146,553	$324,796	$181,881
2001	118	$22,424	$190,358	$44,423	$68,854	($28,932)	$77,467	$352,170	$21,013	$166,176	$349,163	$185,993
2002	120	$21,453	$187,572	$43,268	$84,750	($37,004)	$95,520	$374,106	$31,758	$183,828	$371,144	$190,278
2003	123	$20,450	$183,250	$42,177	$100,284	($45,443)	$113,244	$393,512	$42,507	$191,073	$390,601	$202,440
2004	125	$19,417	$177,188	$41,026	$114,691	($54,039)	$129,868	$408,734	$51,618	$197,045	$407,162	$211,689
2005	128	$18,754	$166,632	$39,815	$112,239	($63,209)	$146,435	$401,912	$56,723	$190,646	$402,284	$211,266
2006	130	$17,700	$163,630	$39,441	$112,628	($67,544)	$146,752	$394,906	$62,200	$194,373	$397,801	$200,533
2007	133	$16,613	$159,628	$38,155	$113,069	($71,800)	$147,077	$386,129	$65,925	$192,110	$391,470	$194,019
2008	136	$15,494	$154,515	$37,763	$113,567	($75,975)	$147,401	$377,272	$68,367	$185,375	$384,979	$191,896
2009	138	$14,344	$148,164	$37,340	$114,050	($80,271)	$147,675	$366,959	$69,540	$178,133	$376,981	$188,825
2010	141	$13,163	$140,439	$36,884	$114,519	($84,688)	$147,897	$355,051	$69,500	$170,355	$367,331	$184,695
2011	144	$12,047	$139,160	$37,328	$115,088	($88,852)	$148,191	$350,915	$70,204	$166,342	$365,394	$184,573
2012	147	$10,887	$137,703	$37,761	$115,762	($92,744)	$148,562	$347,044	$70,426	$162,347	$363,655	$184,697
2013	150	$9,684	$136,037	$38,426	$116,252	($96,485)	$149,421	$343,651	$70,395	$158,641	$362,327	$185,010
2014	153	$8,437	$134,167	$39,097	$116,813	($100,035)	$150,349	$340,390	$70,234	$155,072	$361,075	$185,318
2015	156	$7,139	$132,862	$39,776	$118,457	($104,371)	$152,615	$339,339	$70,368	$152,600	$362,170	$186,739
2016	159	$7,283	$135,540	$40,460	$120,271	($108,361)	$155,064	$342,974	$71,010	$152,126	$367,924	$190,848

Percentage of AFVs leaving county government flee Default: 90%
assumed to be resold and retained in the islands: User Entered: 90%

Age of vehicle (yrs) at sale: 8
Average vehicle life (yrs): 9

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text text text text text text

County Gov

County Gov Fleet Acquisition of Light Duty Alternative Fuel Vehicles

Year	autos	light trucks	new autos	ew light truck	AFVs as %	AFV cars	AFV trucks	AFV cars	AFV trucks	Alcohol		EV		LPG	
1992	1,507	4,514			of new veh	(new)	(new)	cumulative	cumulative	cars	trucks	cars	trucks	cars	trucks
1993	1,538	4,605	192	576	0%	0	3			0	0	0	0	0	3
1994	1,569	4,698	196	587	0%	0	0			0	0	0	0	0	0
1995	1,600	4,793	200	599	0%	0	0			0	0	0	0	0	0
1996	1,632	4,889	204	611	0%	0	0			0	0	0	0	0	0
1997	1,665	4,988	208	623	0%	0	1			0	0	0	0	0	0
1998	1,699	5,088	212	636	0%	0	2			0	1	0	0	0	1
1999	1,733	5,191	217	649	3%	12	16			7	7	2	2	3	7
2000	1,768	5,295	221	662	3%	12	16			7	7	2	2	3	7
2001	1,804	5,402	225	675	3%	12	16			7	7	2	2	3	7
2002	1,840	5,511	230	689	5%	18	25			10	11	3	3	5	11
2003	1,877	5,622	235	703	6%	25	34			14	15	4	4	7	15
2004	1,915	5,735	239	717	8%	32	43			17	18	6	6	9	19
2005	1,954	5,851	244	731	9%	39	53			21	23	7	8	10	22
2006	1,993	5,969	249	746	11%	46	63			25	27	9	9	12	26
2007	2,033	6,089	254	761	11%	47	64			26	27	9	10	12	26
2008	2,074	6,212	259	776	11%	48	65			26	28	10	11	12	27
2009	2,116	6,337	264	792	11%	49	66			26	28	11	11	13	27
2010	2,158	6,465	270	808	11%	50	68			26	28	11	12	13	27
2011	2,202	6,595	275	824	11%	51	69			27	29	12	12	13	28
2012	2,246	6,728	281	841	11%	52	71			27	29	12	13	13	28
2013	2,292	6,863	286	858	11%	53	72			28	30	12	13	13	29
2014	2,338	7,002	292	875	11%	54	73			28	30	13	14	14	29
2015	2,385	7,143	298	893	11%	55	75			28	31	13	14	14	30
2016	2,433	7,287	304	911	11%	57	76			29	31	13	15	14	30

Cumulative light duty AFVs i

cumulative	
Alcohol	EV
0	0
0	0
0	0
0	0
0	0
1	0
15	3
29	7
43	11
64	17
92	25
128	37
172	52
224	70
263	86
302	103
342	121
376	139
403	154
423	167
436	178
442	186
448	194
455	202

Percentage c															3	0		NEW County fleet vehicles
assumed to t		County fleet AFVs																
County Gov	In county fl	Used vehicles sold to local purchasers			Vehicles permanently retired			net additional AFVs to gen. public				Vehicles in fleets under EPACT requirements						
Year		annually			annually			annually				EPACT %	# of new vehicles		Annual AFVs req'd	Annual credits	Cumulative credits	
1992	LPG	Alcohol	EV	LPG	Alcohol	EV	LPG	Alcohol	EV	LPG	total		cars	trucks				
1993	3	0	0	0	0	0	0	0	0	0	0	0%	51	69	0	3	3	768
1994	3	0	0	0	0	0	0	0	0	0	0	0%	52	70	0	3	6	783
1995	3	0	0	0	0	0	0	0	0	0	0	0%	53	72	0	6	12	799
1996	3	0	0	0	0	0	0	0	0	0	0	0%	54	73	0	9	21	815
1997	3	0	0	0	0	0	0	0	0	0	0	0%	55	75	0	12	33	832
1998	4	0	0	0	0	0	0	0	0	0	0	0%	56	76	0	15	48	848
1999	14	0	0	0	0	0	0	0	0	0	0	20%	58	78	27	0	48	865
2000	25	0	0	0	0	0	0	0	0	0	0	20%	59	79	28	0	48	883
2001	32	0	0	3	0	0	0	0	0	2	2	20%	60	81	28	0	48	901
2002	48	0	0	0	0	0	3	0	0	0	0	30%	61	83	43	0	48	919
2003	70	0	0	0	0	0	0	0	0	0	0	40%	62	84	59	0	48	937
2004	97	0	0	0	0	0	0	0	0	0	0	50%	64	86	75	0	48	956
2005	129	0	0	0	0	0	0	0	0	0	0	60%	65	88	91	0	48	976
2006	166	1	0	1	0	0	0	1	0	0	1	70%	66	89	109	0	48	995
2007	195	12	3	9	1	0	1	11	3	8	23	70%	67	91	111	0	48	1,015
2008	224	12	3	9	12	3	9	0	0	0	0	70%	69	93	113	0	48	1,036
2009	253	13	3	9	12	3	9	0	0	0	1	70%	70	95	116	0	48	1,057
2010	277	19	5	14	13	3	9	6	2	5	13	70%	72	97	118	0	48	1,078
2011	296	26	8	19	19	5	14	7	2	5	14	70%	73	99	120	0	48	1,100
2012	311	32	10	25	26	8	19	7	3	5	15	70%	75	101	123	0	48	1,122
2013	321	40	13	29	32	10	25	8	3	5	15	70%	76	103	125	0	48	1,144
2014	326	47	16	34	40	13	29	7	3	5	16	70%	78	105	128	0	48	1,167
2015	331	48	17	35	47	16	34	1	1	0	2	70%	79	107	130	0	48	1,191
2016	336	48	19	35	48	17	35	0	1	0	2	70%	81	109	133	0	48	1,215

Percentage c	NEW		non-AFVs												
assumed to t	County		Non-AFVs Sold to local purchasers			Non-AFVs Permanently retired									
County Gov	AFVs														
Year		non-AFVs	annually			annually		Additional cost for AFV purchases			Additional cost for fuel			Total Additional	Total
1992		sold			LDVs		LDVs	Alcohol	EV	LPG	Alcohol	EV	LPG	All	voluntary
1993	3	691			691		614							Fuels	cost
1994	0	705			705		626								0
1995	0	719			719		639	$11	$68	$28	$7	($2)	$1,468	$1,569	$121
1996	0	733			733		652	$46	$302	$115	$36	($11)	$1,469	$1,912	$536
1997	1	748			748		665	$156	$1,091	$386	$139	($44)	$1,590	$3,162	$1,910
1998	2	763			763		678	$435	$3,227	$1,062	$434	($151)	$1,966	$6,537	$5,577
1999	27	775			775		689	$5,765	$45,272	$12,011	$4,505	($1,789)	$6,631	$66,630	$13,459
2000	28	788			788		700	$5,522	$45,327	$11,334	$8,480	($3,555)	$11,208	$72,793	$27,077
2001	28	801			801		712	$5,300	$44,990	$11,081	$12,376	($5,401)	$14,374	$77,420	$46,491
2002	43	812			812		722	$7,606	$66,501	$16,221	$18,192	($8,335)	$21,159	$113,738	$69,008
2003	59	823			823		731	$9,668	$86,631	$21,065	$25,863	($12,462)	$30,147	$151,244	$90,592
2004	75	831			831		739	$11,475	$104,714	$25,589	$35,314	($17,889)	$41,267	$188,995	$108,041
2005	91	838			838		745	$13,304	$118,207	$29,111	$40,733	($24,805)	$54,512	$217,757	$117,079
2006	109	844			844		750	$14,650	$135,432	$33,651	$52,449	($33,219)	$69,783	$258,096	$127,194
2007	111	853			853		758	$13,751	$132,129	$33,313	$61,139	($40,639)	$81,116	$267,058	$134,517
2008	113	861			861		766	$12,826	$127,907	$32,947	$69,789	($48,335)	$92,405	$274,713	$139,505
2009	116	870			870		774	$11,875	$122,659	$32,552	$78,379	($56,368)	$103,631	$280,853	$142,178
2010	118	881			881		783	$10,898	$116,273	$32,129	$85,304	($63,826)	$112,632	$282,511	$142,490
2011	120	894			894		794	$9,974	$115,217	$32,695	$90,664	($70,298)	$119,500	$287,777	$144,289
2012	123	908			908		807	$9,014	$114,013	$33,267	$94,471	($75,661)	$124,232	$290,322	$145,090
2013	125	925			925		822	$8,018	$112,636	$33,845	$96,530	($79,878)	$127,124	$290,258	$145,286
2014	128	943			943		839	$6,986	$111,091	$34,428	$96,996	($82,820)	$127,919	$287,614	$145,207
2015	130	962			962		855	$5,911	$110,017	$34,926	$98,362	($86,414)	$129,852	$286,743	$145,657
2016	133	982			982		873	$6,030	$112,234	$35,630	$99,868	($89,721)	$131,941	$289,952	$146,801

Percentage c
assumed to t
County Gov

Year	Total EPACT Cost	Total State-Imposed Costs	To be used in cost chart
1992			
1993			
1994	0		
1995	$0	$0	$0
1996	$0	$0	$0
1997	$0	$0	$0
1998	$0	$0	$0
1999	$64,404	$0	$0
2000	$70,600	$0	$0
2001	$76,599	$0	$0
2002	$112,929	$0	$0
2003	$150,460	$0	$0
2004	$188,276	$0	$0
2005	$217,265	$0	$0
2006	$258,096	$0	$0
2007	$267,653	$0	$0
2008	$275,885	$0	$0
2009	$282,589	$0	$0
2010	$285,079	$0	$0
2011	$291,435	$0	$0
2012	$295,311	$0	$0
2013	$298,804	$0	$0
2014	$295,940	$0	$0
2015	$298,886	$0	$0
2016	$301,890	$0	$0

Percentage of AFVs leaving private fleets	Default: 90%	Age of vehicle (yrs) at sale:	3
assumed to be resold and retained in the islands: User Entered:	90%	Average vehicle life (yrs):	9

Private			Private Fleet Acquisition of Light Duty Alternative Fuel Vehicles							Private Fleet Acquisition of Light Duty Alternative Fuel Vehicles					
Year	autos	light trucks	new autos	ew light truc	AFVs as % o	AFV cars	AFV trucks	AFV cars	AFV trucks	Alcohol		EV		LPG	
					New Vehicles	(new)	(new)	cumulative	cumulative	cars	trucks	cars	trucks	cars	trucks
1992	19,232	33,516													
1993	19,620	34,191	7,848	6,838	0%	0	0	0	134	0	0	0	0	0	0
1994	20,015	34,880	8,006	6,976	0%	5	6	5	140	0	0	5	6	0	0
1995	20,419	35,583	8,167	7,117	0%	0	0			0	0	0	0	0	0
1996	20,830	36,300	8,332	7,260	3%	208	182			126	86	23	16	59	80
1997	21,250	37,032	8,500	7,406	5%	425	370			254	173	52	35	120	163
1998	21,678	37,778	8,671	7,556	8%	650	567			383	261	86	59	181	247
1999	22,115	38,540	8,846	7,708	10%	885	771			513	350	128	87	244	333
2000	22,561	39,316	9,024	7,863	14%	1,241	1,081			707	484	195	133	339	464
2001	23,015	40,109	9,206	8,022	18%	1,611	1,404			908	622	266	182	437	599
2002	23,479	40,917	9,392	8,183	21%	1,996	1,739			1,112	763	347	238	537	738
2003	23,952	41,741	9,581	8,348	25%	2,395	2,087			1,314	903	439	302	642	882
2004	24,435	42,583	9,774	8,517	31%	3,054	2,661			1,663	1,144	575	396	816	1,122
2005	24,928	43,441	9,971	8,688	38%	3,739	3,258			2,048	1,419	727	504	964	1,336
2006	25,430	44,316	10,172	8,863	44%	4,450	3,878			2,405	1,667	903	626	1,142	1,584
2007	25,942	45,209	10,377	9,042	50%	5,188	4,521			2,791	1,936	1,070	742	1,328	1,842
2008	26,465	46,120	10,586	9,224	50%	5,293	4,612			2,810	1,953	1,137	790	1,345	1,869
2009	26,998	47,050	10,799	9,410	50%	5,400	4,705			2,845	1,979	1,190	828	1,365	1,898
2010	27,543	47,998	11,017	9,600	50%	5,509	4,800			2,855	1,988	1,268	883	1,385	1,929
2011	28,098	48,965	11,239	9,793	50%	5,620	4,897			2,929	2,037	1,269	882	1,422	1,978
2012	28,664	49,952	11,466	9,990	50%	5,733	4,995			2,977	2,071	1,310	911	1,446	2,013
2013	29,241	50,959	11,697	10,192	50%	5,848	5,096			3,025	2,106	1,352	941	1,471	2,048
2014	29,831	51,986	11,932	10,397	50%	5,966	5,199			3,074	2,142	1,397	973	1,496	2,084
2015	30,432	53,033	12,173	10,607	50%	6,086	5,303			3,119	2,176	1,451	1,012	1,516	2,115
2016	31,045	54,102	12,418	10,820	50%	6,209	5,410			3,182	2,220	1,481	1,033	1,546	2,157

Cumulative AFVs in pri	
	cumulative
Alcohol	EV
0	0
0	11
0	11
212	50
638	126
1,281	271
1,932	447
2,697	688
3,584	991
4,597	1,360
5,623	1,774
6,899	2,296
8,490	2,943
10,345	3,732
12,265	4,573
13,562	5,269
14,314	5,757
14,430	6,095
14,633	6,319
14,856	6,523
15,145	6,665
15,395	6,884
15,642	7,127
15,913	7,347

Percentage c assumed to t		Private fleet AFVs																
Private	vate fleets	Used vehicles sold to local purchasers			Vehicles permanently retired			net additional AFVs to gen. public				Vehicles in fleets under EPACT requirements						Non-AFVs
Year		annually			annually			annually				EPACT %	# of new vehicles		Annual cars	Annual trucks	% of all fleet vehicles	
1992	LPG	Alcohol	EV	LPG	Alcohol	EV	LPG	Alcohol	EV	LPG	total		cars	trucks				
1993	134	0	0	0	0	0	0	0	0	0	0	0	2,343	2,179	0	0	0%	
1994	94	0	0	40	0	0	13	0	0	27	27	0	2,390	2,223	0	0	0%	
1995	54	0	0	40	0	0	13	0	0	27	27	0	2,438	2,268	0	0	0%	
1996	193	0	0	0	0	0	13	0	0	0	0	0	2,487	2,313	0	0	0%	
1997	475	0	10	0	0	0	13	0	10	0	10	0	2,537	2,360	0	0	0%	
1998	904	0	0	0	0	0	13	0	0	0	0	0	2,588	2,407	0	0	0%	
1999	1,342	190	35	125	0	0	13	190	35	112	337	20%	2,640	2,456	528	491	3%	
2000	1,863	384	78	254	0	0	13	384	78	241	702	20%	2,694	2,505	539	501	3%	
2001	2,471	579	130	386	0	0	13	579	130	372	1,082	20%	2,748	2,556	550	511	3%	
2002	3,168	776	194	520	0	0	0	776	194	520	1,490	30%	2,803	2,607	841	782	5%	
2003	3,889	1,072	295	723	0	10	0	1,072	285	723	2,080	40%	2,860	2,660	1,144	1,064	6%	
2004	4,791	1,377	403	933	0	0	0	1,377	403	932	2,713	50%	2,917	2,714	1,459	1,357	8%	
2005	5,815	1,688	526	1,148	190	35	125	1,497	491	1,022	3,010	60%	2,976	2,768	1,786	1,661	10%	
2006	7,017	1,995	667	1,372	384	78	254	1,612	589	1,118	3,318	70%	3,036	2,824	2,125	1,977	11%	
2007	8,250	2,526	874	1,744	579	130	386	1,947	743	1,359	4,049	70%	3,097	2,881	2,168	2,017	11%	
2008	9,165	3,120	1,108	2,070	776	194	520	2,343	915	1,550	4,808	70%	3,160	2,939	2,212	2,057	11%	
2009	9,702	3,665	1,377	2,454	1,072	295	723	2,593	1,082	1,731	5,405	70%	3,223	2,998	2,256	2,099	11%	
2010	9,846	4,254	1,631	2,853	1,377	403	933	2,877	1,228	1,921	6,025	70%	3,288	3,059	2,302	2,141	11%	
2011	10,031	4,287	1,734	2,893	1,688	526	1,148	2,599	1,208	1,746	5,553	70%	3,355	3,120	2,348	2,184	11%	
2012	10,227	4,342	1,816	2,937	1,995	667	1,372	2,347	1,149	1,565	5,060	70%	3,422	3,183	2,396	2,228	11%	
2013	10,431	4,359	1,936	2,983	2,526	874	1,744	1,832	1,062	1,239	4,133	70%	3,491	3,247	2,444	2,273	11%	
2014	10,611	4,469	1,936	3,060	3,120	1,108	2,070	1,349	828	990	3,167	70%	3,562	3,313	2,493	2,319	11%	
2015	10,783	4,543	1,999	3,113	3,665	1,377	2,454	878	622	660	2,160	70%	3,633	3,379	2,543	2,366	11%	
2016	10,967	4,618	2,064	3,167	4,254	1,631	2,853	364	433	314	1,111	70%	3,707	3,448	2,595	2,413	11%	

Percentage c															
assumed to t	non-AFVs														
Private	Sold to local purchasers		Non-AFVs Permanently retired												
Year	annually		annually		Additional cost for AFV purchases			Additional cost for fuel			Total Additional C	Total	Total	Total	To be used
1992		LDVs		LDVs	Alcohol	EV	LPG	Alcohol	EV	LPG	All	voluntary	EPACT	State-	in
1993		16,103		5,368							Fuels	cost	Cost	Imposed	cost
1994		16,437		5,479								0	0	Costs	chart
1995		16,781		5,594	$0	$1,325	$446	$137	($6,100)	$26,167	$21,973	$49,920	$0	$0	$0
1996		17,003		5,668	($4,232)	$645,550	$197,823	$64,864	($26,838)	$91,561	$972,959	$55,560	$0	$953,259	$917,399
1997		17,113		5,704	($17,053)	$1,318,392	$378,238	$193,372	($66,864)	$223,184	$2,046,323	$82,877	$0	$2,020,964	$1,963,445
1998		17,100		5,700	($38,611)	$2,000,590	$539,943	$384,354	($142,522)	$420,045	$3,202,410	$141,627	$0	$3,177,531	$3,060,784
1999		17,080		5,693	($69,003)	$2,668,278	$681,663	$573,828	($233,035)	$617,614	$4,308,348	$266,258	$2,312,426	$4,294,383	$1,995,922
2000		16,989		5,663	($119,120)	$3,605,092	$883,417	$789,334	($353,499)	$844,868	$5,769,212	$475,757	$2,500,740	$5,776,271	$3,268,472
2001		16,823		5,608	($183,660)	$4,481,433	$1,098,411	$1,033,449	($501,793)	$1,103,981	$7,215,482	$765,496	$2,686,120	$7,252,800	$4,529,361
2002		16,581		5,527	($262,528)	$5,260,288	$1,300,525	$1,305,615	($678,473)	$1,394,427	$8,582,383	$1,082,695	$3,694,397	$8,658,337	$4,887,985
2003		16,323		5,441	($77,592)	$5,927,710	$1,493,939	$1,572,701	($871,142)	$1,685,948	$9,809,156	$1,395,782	$4,727,788	$9,935,993	$5,081,368
2004		15,909		5,303	($154,375)	$7,282,536	$1,821,699	$1,899,956	($1,110,573)	$2,044,835	$11,938,453	$1,621,065	$5,892,349	$12,128,040	$6,046,105
2005		15,336		5,112	($259,966)	$8,004,160	$2,069,605	$2,007,864	($1,412,109)	$2,462,374	$13,131,894	$1,650,041	$6,551,950	$13,372,406	$6,579,944
2006		14,596		4,865	$122,164	$9,024,767	$2,399,010	$2,426,999	($1,776,117)	$2,947,377	$15,022,037	$1,745,882	$7,523,532	$15,341,395	$7,498,505
2007		13,819		4,606	$47,267	$10,511,707	$2,726,492	$2,854,146	($2,158,934)	$3,436,985	$17,370,396	$1,801,494	$7,818,386	$17,787,393	$9,552,010
2008		13,377		4,459	$309,595	$10,021,382	$2,700,498	$3,130,196	($2,467,116)	$3,787,213	$17,172,173	$1,801,207	$7,717,763	$17,703,143	$9,454,409
2009		13,283		4,428	$217,104	$9,884,530	$2,675,573	$3,276,712	($2,673,285)	$3,976,073	$17,139,603	$1,794,492	$7,685,552	$17,800,123	$9,454,051
2010		13,551		4,517	$968,571	$9,248,717	$2,651,672	$3,275,936	($2,807,025)	$4,001,762	$16,371,062	$1,810,404	$7,419,399	$17,178,805	$8,951,663
2011		13,824		4,608	$893,748	$10,324,486	$2,719,878	$3,294,104	($2,885,755)	$4,042,883	$17,495,595	$1,929,482	$7,964,299	$18,445,380	$9,531,296
2012		14,103		4,701	$807,682	$10,215,925	$2,767,285	$3,316,239	($2,953,642)	$4,087,241	$17,433,049	$1,934,153	$7,998,068	$18,521,582	$9,434,981
2013		14,388		4,796	$718,416	$10,091,893	$2,815,207	$3,351,960	($2,992,640)	$4,133,519	$17,399,939	$1,940,897	$8,041,896	$18,621,182	$9,358,043
2014		14,678		4,893	$625,875	$9,952,710	$2,863,516	$3,378,176	($3,064,374)	$4,168,638	$17,298,667	$1,941,033	$8,057,971	$18,656,219	$9,240,696
2015		14,974		4,991	$529,524	$9,855,100	$2,904,558	$3,432,426	($3,172,507)	$4,236,049	$17,255,626	$1,944,193	$8,104,282	$18,760,983	$9,151,344
2016		15,276		5,092	$540,195	$10,053,704	$2,963,092	$3,491,761	($3,270,354)	$4,308,672	$17,546,874	$1,960,084	$8,294,567	$19,200,985	$9,252,307

Percentage of AFVs leaving rental car fleets Default: 10%
assumed to be resold and retained in the islands: User Entered: 10%

Age of vehicle (yrs) at sale: 1
Average vehicle life (yrs): 9

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Rental Car			Rental Car Fleet Acquisition of Light Duty Alternative Fuel Vehicles							Rental Car Fleet Acquisition of Light Duty Alternative Fuel Vehicles					
Year	autos	light trucks	new autos	ew light truc	FVs as % o	AFV cars	AFV trucks	AFV cars	AFV trucks	Alcohol		EV		LPG	
1992	38,491	0			New Vehicle	(new)	(new)	cumulative	cumulative	cars	trucks	cars	trucks	cars	trucks
1993	39,267	0	39,267	0	0%	0	0	0	0	0	0	0	0	0	0
1994	40,058	0	40,058	0	0%	0	0	0	0	0	0	0	0	0	0
1995	40,865	0	40,865	0	0%	2	0	2	0	1	0	0	0	1	0
1996	41,689	0	41,689	0	0%	8	0	10	0	5	0	1	0	2	0
1997	42,529	0	42,529	0	0%	30	0	30	0	18	0	4	0	8	0
1998	43,386	0	43,386	0	0%	88	0	88	0	52	0	12	0	25	0
1999	44,260	0	44,260	0	0%	216	0	216	0	125	0	31	0	60	0
2000	45,152	0	45,152	0	3%	1,129	0	1,129	0	643	0	177	0	308	0
2001	46,062	0	46,062	0	5%	2,303	0	2,303	0	1,298	0	380	0	625	0
2002	46,990	0	46,990	0	8%	3,524	0	3,524	0	1,963	0	612	0	949	0
2003	47,937	0	47,937	0	10%	4,794	0	4,794	0	2,630	0	879	0	1,285	0
2004	48,903	0	48,903	0	13%	6,113	0	6,113	0	3,329	0	1,151	0	1,633	0
2005	49,889	0	49,889	0	15%	7,483	0	7,483	0	4,098	0	1,456	0	1,929	0
2006	50,894	0	50,894	0	18%	8,907	0	8,907	0	4,813	0	1,808	0	2,286	0
2007	51,920	0	51,920	0	20%	10,384	0	10,384	0	5,585	0	2,141	0	2,658	0
2008	52,966	0	52,966	0	23%	11,917	0	11,917	0	6,328	0	2,560	0	3,029	0
2009	54,034	0	54,034	0	25%	13,508	0	13,508	0	7,118	0	2,976	0	3,414	0
2010	55,123	0	55,123	0	28%	15,159	0	15,159	0	7,857	0	3,489	0	3,813	0
2011	56,234	0	56,234	0	30%	16,870	0	16,870	0	8,792	0	3,809	0	4,269	0
2012	57,367	0	57,367	0	33%	18,644	0	18,644	0	9,681	0	4,259	0	4,704	0
2013	58,523	0	58,523	0	35%	20,483	0	20,483	0	10,596	0	4,736	0	5,152	0
2014	59,702	0	59,702	0	38%	22,388	0	22,388	0	11,535	0	5,241	0	5,612	0
2015	60,905	0	60,905	0	40%	24,362	0	24,362	0	12,485	0	5,809	0	6,067	0
2016	62,133	0	62,133	0	40%	24,853	0	24,853	0	12,737	0	5,926	0	6,190	0

Cumulative AFVs in re	
	cumulative
Alcohol	EV
0	0
0	0
1	0
5	1
18	4
52	12
125	31
643	177
1,298	380
1,963	612
2,630	879
3,329	1,151
4,098	1,456
4,813	1,808
5,585	2,141
6,328	2,560
7,118	2,976
7,857	3,489
8,792	3,809
9,681	4,259
10,596	4,736
11,535	5,241
12,485	5,809
12,737	5,926

Percentage c																	
assumed to t		Rental fleet AFVs															
Rental Car	ntal fleets	Used vehicles sold to local purchasers			Vehicles permanently retired			net additional AFVs to gen. public									Non-AFVs
Year		annually			annually				annually								
1992	LPG	Alcohol	EV	LPG	Alcohol	EV	LPG	Alcohol	EV	LPG	total	State require	# of new car	# of new truc	AFVs requir	AFVs as % of new vehicles	
1993	0	0	0	0	0	0	0	0	0	0	0	0	27,281	0	0	0%	
1994	0	0	0	0	0	0	0	0	0	0	0	0	27,830	0	0	0%	
1995	1	0	0	0	0	0	0	0	0	0	0	0	28,391	0	0	0%	
1996	2	0	0	0	0	0	0	0	0	0	0	0	28,963	0	0	0%	
1997	8	1	0	0	0	0	0	1	0	0	1	0	29,547	0	0	0%	
1998	25	2	0	1	0	0	0	2	0	1	3	0	30,142	0	0	0%	
1999	60	5	1	2	0	0	0	5	1	2	9	0	30,750	0	0	0%	
2000	308	13	3	6	0	0	0	13	3	6	22	0	31,370	0	0	0%	
2001	625	64	18	31	0	0	0	64	18	31	113	0	32,002	0	0	0%	
2002	949	130	38	62	0	0	0	130	38	62	230	0	32,647	0	0	0%	
2003	1,285	196	61	95	0	0	0	196	61	95	352	0	33,305	0	0	0%	
2004	1,633	263	88	128	0	0	0	263	88	128	479	0	33,976	0	0	0%	
2005	1,929	333	115	163	1	0	0	332	115	163	610	0	34,660	0	0	0%	
2006	2,286	410	146	193	2	0	1	408	145	192	745	0	35,359	0	0	0%	
2007	2,658	481	181	229	5	1	2	476	180	226	882	0	36,072	0	0	0%	
2008	3,029	559	214	266	13	3	6	546	211	260	1,017	0	36,798	0	0	0%	
2009	3,414	633	256	303	64	18	31	568	238	272	1,079	0	37,540	0	0	0%	
2010	3,813	712	298	341	130	38	62	582	260	279	1,121	0	38,297	0	0	0%	
2011	4,269	786	349	381	196	61	95	589	288	286	1,163	0	39,068	0	0	0%	
2012	4,704	879	381	427	263	88	128	616	293	298	1,208	0	39,856	0	0	0%	
2013	5,152	968	426	470	333	115	163	635	311	307	1,253	0	40,659	0	0	0%	
2014	5,612	1,060	474	515	410	146	193	650	328	322	1,300	0	41,478	0	0	0%	
2015	6,067	1,154	524	561	481	181	229	672	343	333	1,348	0	42,314	0	0	0%	
2016	6,190	1,249	581	607	559	214	266	690	367	341	1,398	0	43,167	0	0	0%	

Percentage c															
assumed to t	non-AFVs														
Rental Car	Sold to local purchasers		Non-AFVs Permanently retired												
Year	annually		annually		Additional cost for AFV purchases			Additional cost for fuel			Total Additional C	Total	Total	Total	To be used
1992		LDVs		LDVs	Alcohol	EV	LPG	Alcohol	EV	LPG	All	voluntary	EPACT	State-	in
1993		3,927		436							Fuels	cost	Cost	Imposed	cost
1994		4,006		445								0	0	Costs	chart
1995		4,086		454	$0	$3,542	$813	$366	($108)	$264	$4,876	$4,876	$0	$0	$0
1996		4,168		463	($101)	$15,472	$3,376	$1,551	($501)	$1,127	$21,026	$21,381	$0	$0	$0
1997		4,250		472	($716)	$55,375	$11,309	$5,424	($1,938)	$3,962	$74,133	$75,810	$0	$0	$0
1998		4,330		481	($3,121)	$161,720	$31,060	$15,603	($6,172)	$11,459	$213,669	$219,556	$0	$0	$0
1999		4,404		489	($10,014)	$387,216	$70,368	$37,170	($16,284)	$27,445	$505,915	$523,433	$0	$0	$0
2000		4,402		489	($64,336)	$1,947,095	$339,281	$188,275	($90,963)	$139,888	$2,523,577	$1,034,418	$0	$2,523,577	$1,489,159
2001		4,376		486	($155,780)	$3,801,132	$662,323	$374,302	($192,458)	$279,211	$4,924,511	$1,741,024	$0	$5,134,847	$3,183,487
2002		4,347		483	($274,887)	$5,507,914	$967,795	$557,668	($305,228)	$417,646	$7,145,795	$2,522,392	$0	$7,761,731	$4,623,403
2003		4,314		479	($92,043)	$7,031,683	$1,259,283	$735,580	($431,724)	$557,032	$9,151,853	$3,324,125	$0	$10,352,363	$5,827,728
2004		4,279		475	($183,071)	$8,636,234	$1,534,905	$916,679	($556,870)	$696,932	$11,227,880	$3,951,752	$0	$13,172,741	$7,276,128
2005		4,241		471	($307,362)	$9,463,452	$1,736,342	$969,211	($698,487)	$816,884	$12,287,402	$4,095,082	$0	$14,834,430	$8,192,320
2006		4,199		467	$144,382	$10,666,147	$2,011,636	$1,129,081	($860,362)	$960,148	$13,906,650	$4,489,460	$0	$17,404,251	$9,417,190
2007		4,154		462	$55,850	$12,420,540	$2,285,459	$1,299,667	($1,010,912)	$1,107,188	$16,101,943	$4,820,957	$0	$20,668,311	$11,280,986
2008		4,105		456	$411,308	$13,313,777	$2,544,582	$1,460,520	($1,198,795)	$1,251,785	$17,371,870	$5,025,490	$0	$23,147,135	$12,346,380
2009		4,053		450	$320,324	$14,584,042	$2,799,306	$1,629,474	($1,382,120)	$1,399,091	$19,029,793	$5,216,539	$0	$26,108,573	$13,813,254
2010		3,996		444	$1,571,354	$15,004,587	$3,050,015	$1,783,617	($1,606,965)	$1,549,561	$19,780,814	$5,471,544	$0	$28,270,473	$14,309,270
2011		3,936		437	$1,582,587	$18,281,885	$3,415,341	$1,979,289	($1,739,352)	$1,720,669	$23,657,832	$5,984,935	$0	$33,617,184	$17,672,897
2012		3,872		430	$1,548,981	$19,592,214	$3,763,106	$2,161,057	($1,928,676)	$1,879,904	$25,467,605	$6,186,773	$0	$37,092,738	$19,280,832
2013		3,804		423	$1,483,384	$20,837,715	$4,121,233	$2,345,094	($2,126,305)	$2,041,320	$27,219,056	$6,380,597	$0	$40,630,332	$20,838,460
2014		3,731		415	$1,384,234	$22,012,180	$4,489,635	$2,531,195	($2,332,946)	$2,204,742	$28,904,806	$6,566,076	$0	$44,217,835	$22,338,730
2015		3,654		406	$1,248,548	$23,237,024	$4,853,922	$2,739,697	($2,585,898)	$2,383,633	$30,628,378	$6,774,970	$0	$48,104,099	$23,853,408
2016		3,728		414	$1,273,709	$23,705,306	$4,951,740	$2,794,908	($2,638,010)	$2,431,669	$31,245,613	$7,025,215	$0	$51,005,022	$24,220,398

Percentage of AFVs leaving individual owners				Default:	90%		Age of vehicle (yrs) at sale:		5	text	text	text	text	text	text
assumed to be resold and retained in the islands:				User Entered:	90%		Average vehicle life (yrs):		9	text	text	text	text	text	text
Private Indi	Private Individual Acquisition of Light Duty AFVs				New AFVs purchased by individuals					Voluntary purchases					
Year	Cars	Light Trucks	new autos	ew light truck	AFVs as %	AFV cars	AFV trucks	AFV cars	AFV trucks	Alcohol		EV		LPG	
1992	69,832	2,450	27,933	490	of new veh.	(new)	(new)	cumulative	cumulative	cars	trucks	cars	trucks	cars	trucks
1993	71,240	2,499	28,496	500	0%	0	0	5	2	0	0	0	0	0	0
1994	72,675	2,550	29,070	510	0%	1	0	6	2	1	0	0	0	0	0
1995	74,140	2,601	29,656	520	0%	1	0	7	2	1	0	0	0	0	0
1996	75,634	2,653	30,254	531	0%	6	0	14	2	4	0	1	0	2	0
1997	77,158	2,707	30,863	541	0%	22	0	34	3	13	0	3	0	6	0
1998	78,713	2,761	31,485	552	0%	64	1	97	4	37	1	10	0	18	1
1999	80,299	2,817	32,120	563	0%	157	4	249	7	89	2	25	0	43	2
2000	81,918	2,874	32,767	575	1%	322	7	549	14	180	3	55	1	87	3
2001	83,568	2,932	33,427	586	2%	559	12	1,044	25	309	5	100	2	150	5
2002	85,253	2,991	34,101	598	2%	835	19	1,721	40	457	8	156	3	223	8
2003	86,971	3,051	34,788	610	3%	1,097	24	2,496	57	592	10	214	4	292	10
2004	88,723	3,113	35,489	623	4%	1,307	29	3,244	74	700	12	260	5	346	12
2005	90,511	3,175	36,205	635	4%	1,465	32	3,874	88	791	14	299	5	376	13
2006	92,335	3,239	36,934	648	4%	1,552	34	4,329	97	827	15	329	6	396	14
2007	94,196	3,305	37,678	661	4%	1,609	35	4,632	104	854	15	346	6	409	14
2008	96,094	3,371	38,438	674	4%	1,654	36	4,820	108	867	15	368	6	418	15
2009	98,031	3,439	39,212	688	4%	1,696	37	4,964	111	883	15	386	7	426	15
2010	100,006	3,508	40,003	702	4%	1,733	38	5,088	114	889	16	410	7	434	15
2011	102,022	3,579	40,809	716	4%	1,772	39	5,206	116	913	16	413	7	446	16
2012	104,078	3,651	41,631	730	4%	1,814	40	5,325	119	931	16	427	7	455	16
2013	106,175	3,725	42,470	745	4%	1,857	41	5,448	121	950	17	442	8	465	16
2014	108,315	3,800	43,326	760	4%	1,900	42	5,576	124	969	17	457	8	474	17
2015	110,498	3,877	44,199	775	4%	1,940	42	5,702	127	984	17	475	8	481	17
2016	112,724	3,955	45,090	791	4%	1,940	42	5,786	129	984	17	475	8	481	17

Cumulative AFVs owned b	
	cumulative
Alcohol	EV
1	6
2	5
2	4
6	4
19	6
56	16
146	41
328	97
639	198
1,091	354
1,655	561
2,276	801
2,898	1,049
3,425	1,281
3,830	1,475
4,110	1,633
4,296	1,761
4,396	1,874
4,484	1,960
4,563	2,043
4,647	2,118
4,734	2,190
4,831	2,255
4,903	2,318

Percentage c																	
assumed to t		Individuals' AFVs										non-AFVs					
Private Indi	y Individua	Used vehicles sold to local purchasers			Vehicles permanently retired			net additional AFVs to gen. public				Non-AFVs Sold to local purchasers			Non-AFVs Permanently retired		
Year		annually			annually				annually			annually			annually		Additional
1992	LPG	Alcohol	EV	LPG	Alcohol	EV	LPG	Alcohol	EV	LPG	total			LDVs		LDVs	Alcohol
1993	0	0	0	0	0	0	0	0	0	0	0			13,272		7,373	
1994	0	0	1	0	0	1	0	0	0	0	1			13,539		7,522	
1995	0	0	1	0	0	1	0	0	0	0	1			13,812		7,673	$0
1996	2	0	1	0	0	1	0	0	0	0	1			14,090		7,828	($73)
1997	8	0	1	0	0	1	0	0	0	0	1			14,370		7,983	($519)
1998	27	0	0	0	0	1	0	0	0	0	0			14,648		8,138	($2,262)
1999	71	1	0	0	0	1	0	1	0	0	1			14,914		8,286	($7,261)
2000	161	1	0	0	0	1	0	1	0	0	1			15,157		8,420	($18,308)
2001	315	3	1	2	0	1	0	3	0	2	5			15,363		8,535	($37,704)
2002	539	12	3	6	0	0	0	12	3	6	20			15,527		8,626	($65,032)
2003	823	34	9	17	1	0	0	33	9	17	58			15,657		8,698	($21,073)
2004	1,137	82	23	40	1	0	0	81	23	40	144			15,772		8,762	($39,161)
2005	1,435	165	51	81	3	1	2	161	50	80	291			15,895		8,830	($60,345)
2006	1,690	283	92	140	12	3	6	271	89	134	494			16,052		8,918	$25,251
2007	1,883	418	143	208	34	9	17	384	134	191	709			16,258		9,031	$8,689
2008	2,014	542	196	272	82	23	40	460	173	232	865			16,508		9,171	$57,365
2009	2,096	641	239	323	165	51	81	476	188	241	905			16,797		9,332	$40,421
2010	2,157	724	274	350	283	92	140	441	182	210	834			17,116		9,509	$180,939
2011	2,208	758	301	369	418	143	208	339	158	161	659			17,451		9,695	$167,252
2012	2,256	782	317	381	542	196	272	240	121	110	471			17,796		9,887	$151,647
2013	2,304	794	337	389	641	239	323	153	99	67	319			18,150		10,083	$135,332
2014	2,353	808	354	397	724	274	350	84	80	47	211			18,511		10,284	$118,285
2015	2,403	814	376	404	758	301	369	57	75	35	167			18,879		10,489	$100,138
2016	2,439	836	378	415	782	317	381	54	62	34	150			19,263		10,702	$100,138

Percentage c
assumed to t
Private Indi

Year	cost for AFV purchases		Additional cost for fuel			Total Additional Cos	Total	tal Additional Cc
1992	EV	LPG	Alcohol	EV	LPG	All	voluntary	All
1993						Fuels	cost	Fuels
1994							0	0
1995	$3,108	$607	$779	($2,211)	$197	$2,481	$1,404	$0
1996	$13,351	$2,519	$1,829	($2,007)	$1,033	$16,724	$15,075	$0
1997	$47,007	$8,436	$5,685	($3,058)	$3,979	$62,049	$59,450	$0
1998	$135,120	$23,167	$16,937	($8,185)	$12,486	$179,524	$175,202	$0
1999	$318,608	$52,486	$43,422	($21,502)	$32,833	$425,847	$416,577	$0
2000	$619,107	$99,264	$96,122	($50,024)	$73,100	$837,569	$817,315	$0
2001	$1,016,991	$164,789	$184,241	($100,372)	$140,699	$1,406,348	$1,368,871	$0
2002	$1,425,283	$235,322	$309,734	($176,313)	$237,376	$2,031,401	$1,965,114	$0
2003	$1,740,710	$295,942	$462,894	($275,702)	$356,709	$2,580,555	$2,559,617	$0
2004	$1,987,533	$336,970	$626,851	($387,184)	$485,230	$3,049,400	$3,013,527	$0
2005	$1,978,967	$349,815	$685,299	($503,167)	$607,735	$3,118,649	$3,066,451	$0
2006	$1,972,895	$360,612	$803,553	($609,872)	$709,684	$3,236,871	$3,279,264	$0
2007	$2,042,077	$364,468	$891,165	($696,389)	$784,395	$3,385,717	$3,424,355	$0
2008	$1,949,560	$363,530	$948,636	($764,377)	$832,050	$3,329,399	$3,432,656	$0
2009	$1,926,795	$361,835	$983,471	($817,637)	$859,140	$3,313,604	$3,418,224	$0
2010	$1,795,776	$359,194	$998,045	($862,979)	$876,535	$3,166,571	$3,431,221	$0
2011	$2,018,339	$369,215	$1,009,403	($895,089)	$890,063	$3,391,931	$3,662,388	$0
2012	$2,000,180	$376,928	$1,018,506	($925,015)	$901,492	$3,372,092	$3,646,465	$0
2013	$1,978,892	$384,747	$1,028,471	($950,755)	$912,917	$3,354,273	$3,631,136	$0
2014	$1,954,524	$392,657	$1,038,853	($974,720)	$924,565	$3,335,878	$3,614,024	$0
2015	$1,933,162	$398,520	$1,060,070	($1,003,951)	$943,876	$3,331,676	$3,610,576	$0
2016	$1,933,162	$398,520	$1,075,915	($1,031,907)	$958,267	$3,333,955	$3,632,658	$0

Used cars	AFV Accumulation in "Public Fleet", i.e. Fleet AFVs Resold on the Islands			
	Alcohol	EV	LPG	Total AFV
Year	cumulative	cumulative	cumulative	cumulative
1993	0	0	0	0
1994	0	0	27	27
1995	0	1	54	55
1996	0	1	54	55
1997	1	12	54	67
1998	8	12	55	75
1999	210	49	169	427
2000	610	130	418	1,159
2001	1,306	287	861	2,453
2002	2,281	533	1,498	4,312
2003	3,673	907	2,406	6,987
2004	5,536	1,454	3,619	10,610
2005	7,627	2,139	4,963	14,730
2006	10,050	3,000	6,510	19,561
2007	12,922	4,083	8,338	25,343
2008	16,277	5,396	10,386	32,059
2009	19,951	6,927	12,662	39,539
2010	23,898	8,623	15,104	47,625
2011	27,473	10,304	17,331	55,109
2012	30,725	11,896	19,338	61,958
2013	33,367	13,387	20,960	67,714
2014	35,466	14,643	22,333	72,443
2015	37,083	15,704	23,369	76,155
2016	38,202	16,584	24,067	78,852

Used AFVs purchased						Used in	Cum	Cum	Total
from Fed	from State	from County	from Private	from Rental	from Indiv	per year	In	Retirements	on road
0	0	0	0	0	0	0	0	0	0
0	0	0	40	0	1	42	42	15	27
0	0	0	40	0	1	42	83	29	54
0	0	0	0	0	1	2	85	44	41
0	0	0	10	1	1	12	97	58	39
5	0	0	1	3	0	8	106	73	33
5	0	0	351	9	1	366	472	87	384
6	0	0	716	22	1	745	1,217	102	1,115
91	2	3	1,095	113	6	1,309	2,526	117	2,410
123	0	0	1,490	230	20	1,863	4,389	126	4,264
189	0	0	2,090	352	59	2,691	7,080	142	6,938
290	5	0	2,713	479	145	3,632	10,712	150	10,562
296	7	1	3,361	611	297	4,573	15,285	603	14,682
302	100	2	4,034	748	514	5,700	20,985	1,473	19,512
308	102	24	5,144	891	768	7,237	28,222	2,927	25,295
314	104	25	6,297	1,038	1,009	8,788	37,010	5,000	32,010
384	106	25	7,495	1,192	1,202	10,405	47,415	7,924	39,491
392	108	39	8,738	1,351	1,348	11,976	59,391	11,815	47,576
400	110	53	8,915	1,516	1,427	12,421	71,812	16,751	55,061
408	113	67	9,094	1,687	1,480	12,849	84,661	22,751	61,910
416	115	82	9,277	1,864	1,521	13,277	97,938	30,273	67,665
425	117	98	9,464	2,048	1,559	13,712	111,650	39,256	72,394
433	120	100	9,655	2,239	1,594	14,141	125,791	49,684	76,107
442	122	102	9,850	2,436	1,630	14,582	140,373	61,569	78,804

from Fed
382
388
395
385
368
340
291
242
209
181
165
156
146
136
126
116
118
121
123
125
128
131
133
136

Used cars

	Used non-AFVs purchased					Used in	Cum	Cum	Additional	Additional cost for fuel			Total Additiona	Total
Year	from State	from County	from Private	from Rental	from Indiv	per year	In	Retirements	on road	Alcohol	EV	LPG	All Fuels	voluntary cost
.1993	362	691	16,103	3,927	13,272	34,736	34,736	14,325	20,411					
1994	369	705	16,437	4,006	13,539	35,444	70,180	28,941	41,239					
1995	376	719	16,781	4,086	13,812	36,170	106,349	43,855	62,495	$66	($529)	$26,022	$25,559	$25,559
1996	383	733	17,003	4,168	14,090	36,762	143,111	59,019	84,092	$132	($784)	$25,400	$24,748	$24,748
1997	390	748	17,113	4,250	14,370	37,239	180,350	74,395	105,955	$316	($6,348)	$25,264	$19,232	$19,232
1998	386	763	17,100	4,330	14,648	37,566	217,916	89,924	127,992	$2,325	($6,512)	$25,407	$21,220	$21,220
1999	381	775	17,080	4,404	14,914	37,846	255,763	105,582	150,181	$62,249	($25,309)	$77,834	$114,773	$114,773
2000	376	788	16,989	4,402	15,157	37,954	293,717	121,324	172,393	$178,622	($66,969)	$189,562	$301,214	$301,214
2001	372	801	16,823	4,376	15,363	37,944	331,661	137,111	194,549	$376,455	($145,079)	$384,845	$616,222	$616,222
2002	367	812	16,581	4,347	15,527	37,815	369,475	152,896	216,579	$647,963	($265,667)	$659,233	$1,041,528	$1,041,528
2003	362	823	16,323	4,314	15,657	37,643	407,119	168,659	238,460	$1,027,339	($445,732)	$1,043,060	$1,624,668	$1,624,668
2004	357	831	15,909	4,279	15,772	37,304	444,423	184,342	260,081	$1,524,728	($703,360)	$1,544,719	$2,366,087	$2,366,087
2005	353	838	15,336	4,241	15,895	36,808	481,231	199,896	281,335	$1,803,808	($1,026,426)	$2,101,484	$2,878,867	$2,878,867
2006	360	844	14,596	4,199	16,052	36,186	517,418	215,291	302,127	$2,357,828	($1,427,762)	$2,734,407	$3,664,473	$3,664,473
2007	367	853	13,819	4,154	16,256	35,575	552,992	230,544	322,448	$3,006,970	($1,927,568)	$3,473,822	$4,553,224	$4,553,224
2008	374	861	13,377	4,105	16,508	35,341	588,333	245,793	342,540	$3,756,849	($2,526,364)	$4,291,875	$5,522,360	$5,522,360
2009	382	870	13,283	4,053	16,797	35,503	623,836	261,181	362,655	$4,566,976	($3,216,634)	$5,189,236	$6,539,578	$6,539,578
2010	390	881	13,551	3,996	17,116	36,054	659,890	276,848	383,043	$5,425,159	($3,970,935)	$6,139,011	$7,593,235	$7,593,235
2011	397	894	13,824	3,936	17,451	36,625	696,516	292,804	403,712	$6,184,763	($4,705,773)	$6,985,270	$8,464,260	$8,464,260
2012	405	908	14,103	3,872	17,796	37,211	733,726	309,059	424,667	$6,858,522	($5,386,637)	$7,728,349	$9,200,234	$9,200,234
2013	414	925	14,388	3,804	18,150	37,808	771,534	325,622	445,912	$7,385,071	($6,010,361)	$8,305,368	$9,680,077	$9,680,077
2014	422	943	14,678	3,731	18,511	38,416	809,950	342,499	467,451	$7,782,409	($6,518,234)	$8,773,667	$10,037,841	$10,037,841
2015	430	962	14,974	3,654	18,879	39,034	848,983	359,697	489,287	$8,137,079	($6,990,289)	$9,180,633	$10,327,424	$10,327,424
2016	439	982	15,276	3,728	19,263	39,824	888,808	377,244	511,564	$8,382,605	($7,382,173)	$9,454,796	$10,455,228	$10,455,228

Total AFVs

Year	Alcohol cumulative	EV cumulative	LPG cumulative	Total AFV cumulative
1993	8	6	137	151
1994	15	16	123	155
1995	21	17	113	151
1996	295	66	298	660
1997	822	171	650	1,643
1998	1,703	368	1,238	3,309
1999	2,944	679	2,048	5,671
2000	5,039	1,262	3,334	9,635
2001	7,768	2,080	4,994	14,842
2002	11,049	3,139	7,013	21,201
2003	14,845	4,458	9,378	28,681
2004	19,440	6,099	12,260	37,799
2005	24,661	8,046	15,330	48,037
2006	30,285	10,338	18,763	59,386
2007	36,345	12,847	22,454	71,646
2008	42,114	15,491	25,986	83,591
2009	47,579	18,105	29,305	94,989
2010	52,531	20,818	32,389	105,739
2011	57,378	23,178	35,344	115,900
2012	61,863	25,551	38,059	125,473
2013	65,828	27,777	40,410	134,014
2014	69,234	29,866	42,497	141,597

Privately owned AFVs

Year	Alcohol cumulative	EV cumulative	LPG cumulative	Private AFV cumulative
1993	1	6	134	141
1994	29	16	94	139
1995	59	15	55	129
1996	279	55	198	531
1997	742	135	492	1,369
1998	1,465	298	960	2,722
1999	2,631	519	1,478	4,629
2000	4,828	962	2,339	8,129
2001	7,975	1,569	3,501	13,045
2002	11,963	2,326	4,779	19,067
2003	16,894	3,214	6,186	26,294
2004	23,114	4,249	7,851	35,213
2005	30,216	5,448	9,476	45,139
2006	38,144	6,821	11,294	56,259
2007	47,023	8,190	13,098	68,310
2008	56,058	9,462	14,522	80,042
2009	65,268	10,494	15,596	91,358
2010	74,308	11,459	16,207	101,974
2011	83,017	12,088	16,908	112,014
2012	91,058	12,825	17,595	121,477
2013	98,101	13,519	18,303	129,923
2014	104,107	14,315	19,001	137,423

Non-government AFVs in Analysis Years:

Year	New	On road
1993	0	141
1994	12	180
1995	4	38
1996	404	13
1997	848	54
1998	1,371	180
1999	2,032	783
2000	3,780	2,336
2001	5,889	4,423
2002	8,113	6,792
2003	10,398	9,483
2004	13,164	12,252
2005	15,978	14,701
2006	18,820	17,068
2007	21,738	19,702
2008	23,513	22,236
2009	25,346	24,465
2010	27,238	26,669
2011	29,197	27,913
2012	31,226	29,263
2013	33,324	30,286
2014	35,495	31,531

Total Additional C All Fuels	ALL FL Total voluntary cost
0	0
$78,802	$88,977
$1,304,111	$124,577
$2,592,622	$247,687
$4,429,652	$573,403
$6,569,428	$1,350,106
$10,793,722	$2,683,673
$15,595,562	$4,581,221
$20,320,163	$6,746,813
$24,745,452	$9,081,316
$30,323,235	$11,163,692
$33,114,451	$11,919,035
$37,557,526	$13,426,681
$43,131,567	$14,860,361
$45,103,191	$16,049,901
$47,695,735	$17,240,417
$48,539,654	$18,577,163
$54,630,545	$20,314,530
$57,085,201	$21,242,294
$59,255,521	$21,907,735
$61,167,754	$22,433,987

Total AFVs .EETS

Year	Total EPACT Cost	Total State-Imposed Costs	To be used in cost chart
1993			
1994	0		
1995	$24,695	$0	$0
1996	$269,171	$953,259	$917,399
1997	$390,185	$2,020,964	$1,963,445
1998	$622,584	$3,396,411	$3,247,425
1999	$3,358,627	$4,545,531	$2,165,123
2000	$3,682,042	$8,624,645	$4,939,512
2001	$3,938,337	$12,736,810	$7,898,842
2002	$5,032,000	$16,791,211	$9,701,666
2003	$6,118,737	$20,678,957	$11,111,536
2004	$7,444,061	$25,707,943	$13,533,922
2005	$8,066,104	$28,609,120	$14,983,530
2006	$9,085,682	$33,143,447	$17,116,227
2007	$9,387,197	$38,847,174	$21,027,015
2008	$9,282,966	$41,235,257	$21,992,686
2009	$9,227,927	$44,285,677	$23,456,130
2010	$8,929,089	$45,816,610	$23,445,628
2011	$9,475,505	$52,427,957	$27,388,766
2012	$9,508,923	$55,977,975	$28,900,510
2013	$9,550,881	$59,613,840	$30,381,513
2014	$9,563,513	$63,235,130	$31,764,745

Buses

					AFVs as % of new vehicle		New vehicles		Cumulative AFVs		Total
Year	under 8.5K (light duty)	8.5K-26K	26K+	total	8.5K-26K	26K+	8.5K-26K	26K+	8.5K-26K	26K+	AF buses
1990	1077	1077	2154	4308	1%	1%	120	180	17	27	44
1991	1101	1101	2203	4405	1%	1%	122	184	15	23	38
1992	1126	1126	2251	4503	1%	1%	125	188	12	19	31
1993	1150	1150	2300	4600	1%	1%	128	192	10	15	25
1994	1174	1174	2349	4697	1%	1%	130	196	9	13	22
1995	1199	1199	2397	4795	0%	0%	133	200	6	9	16
1996	1223	1223	2446	4892	0%	0%	136	204	4	6	9
1997	1243	1243	2486	4973	0%	0%	138	207	1	2	3
1998	1263	1263	2527	5053	0%	0%	140	211	2	3	4
1999	1284	1284	2567	5134	1%	1%	143	214	2	4	6
2000	1304	1304	2607	5215	1%	1%	145	217	4	6	10
2001	1324	1324	2648	5295	2%	2%	147	221	7	10	17
2002	1344	1344	2688	5376	3%	3%	149	224	10	15	24
2003	1364	1364	2728	5456	4%	4%	152	227	15	23	38
2004	1384	1384	2769	5537	4%	4%	154	231	21	32	53
2005	1404	1404	2809	5618	5%	5%	156	234	28	43	71
2006	1425	1425	2849	5698	5%	5%	158	237	35	53	89
2007	1445	1445	2889	5779	5%	5%	161	241	42	64	106
2008	1465	1465	2930	5859	5%	5%	163	244	48	73	121
2009	1485	1485	2970	5940	5%	5%	165	248	53	81	134
2010	1505	1505	3010	6021	5%	5%	167	251	57	87	144
2011	1525	1525	3051	6101	5%	5%	169	254	60	91	151
2012	1545	1545	3091	6182	5%	5%	172	258	62	94	156
2013	1566	1566	3131	6262	5%	5%	174	261	64	96	160
2014	1586	1586	3172	6343	5%	5%	176	264	65	98	163
beyond 2014	1606	1606	3212	6424	5%	5%	178	268	66	100	166
beyond 2014	1626	1626	3252	6504	5%	5%	181	271	65	98	163

New AFVs by fuel type			Cumulative AFVs by fuel type		
Alcohol	Electricity	LPG	Alcohol	Electricity	LPG
0	0	0	0	0	44
0	0	0	0	0	38
0	0	0	0	0	31
0	0	0	0	0	25
0	3	0	0	3	19
0	0	0	0	3	13
0	0	0	0	3	6
0	0	0	0	3	0
0	0	0	1	3	1
1	0	1	1	3	1
2	0	2	3	4	3
3	1	3	6	5	6
5	1	4	11	3	10
6	2	6	17	5	16
7	2	7	23	7	23
8	3	7	31	10	30
8	3	8	39	13	37
8	3	8	46	16	44
8	3	8	52	19	50
8	4	8	58	21	55
8	4	8	62	24	59
9	4	8	64	25	62
9	4	8	66	27	63
9	4	9	67	28	65
9	4	9	68	29	66
9	4	9	69	30	67
4	4	9	65	31	67

Buses	Retirements by fuel type		
Year	Alcohol	Electricity	LPG
1990	0	0	6
1991	0	0	6
1992	0	0	6
1993	0	0	6
1994	0	0	6
1995	0	0	6
1996	0	0	6
1997	0	0	6
1998	0	0	0
1999	0	0	0
2000	0	0	0
2001	0	0	0
2002	0	3	0
2003	0	0	0
2004	0	0	0
2005	0	0	0
2006	0	0	0
2007	1	0	1
2008	2	0	2
2009	3	1	3
2010	5	1	4
2011	6	2	6
2012	7	2	7
2013	8	3	7
2014	8	3	8
beyond 2014	8	3	8
beyond 2014	8	3	8

Annual fuel consumption per vehicle from Chapter 2									
Year	Average fuel consumption (GEG/veh/yr.)				Analysis year?	mpg	8,806	% of 1995	kWh/mi
1995	455.08	455.08	455.08	455.08	no	19		100%	0.358
1996	452.06	452.06	452.06	452.06	yes	19		99%	0.356
1997	448.01	448.01	448.01	448.01	no	20		98%	0.352
1998	443.96	443.96	443.96	443.96	no	20		98%	0.349
1999	439.91	439.91	439.91	439.91	yes	20		97%	0.346
2000	433.86	433.86	433.86	433.86	no	20		95%	0.341
2001	427.80	427.80	427.80	427.80	no	21		94%	0.337
2002	421.75	421.75	421.75	421.75	no	21		93%	0.332
2003	415.70	415.70	415.70	415.70	no	21		91%	0.327
2004	409.65	409.65	409.65	409.65	yes	21		90%	0.322
2005	406.71	406.71	406.71	406.71	no	22		89%	0.320
2006	403.76	403.76	403.76	403.76	no	22		89%	0.318
2007	400.82	400.82	400.82	400.82	no	22		88%	0.315
2008	397.87	397.87	397.87	397.87	no	22		87%	0.313
2009	394.93	394.93	394.93	394.93	no	22		87%	0.311
2010	391.98	391.98	391.98	391.98	no	22		86%	0.308
2011	389.04	389.04	389.04	389.04	no	23		85%	0.306
2012	386.09	386.09	386.09	386.09	no	23		85%	0.304
2013	383.14	383.14	383.14	383.14	no	23		84%	0.301
2014	380.20	380.20	380.20	380.20	yes	23		84%	0.299

APPENDIX A-5

SCENARIO BUILDER (PC Format) DISCS
(five disc set)

AND

HAWAII BIORESOURCE DATA (Macintosh Format) DISC

ARE AVAILABLE FROM:

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