OCS Report
MMS 96-0049

Energy Alternatives and the Environment

Revised August 1996

U.S. Department of the Interior
Minerals Management Service

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The Department of the Interior Mission

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

The Minerals Management Service Mission

As a bureau of the Department of the Interior, the Minerals Management Service's (MMS) primary responsibilities are to manage the mineral resources located on the Nation's Outer Continental Shelf (OCS), collect revenue from the Federal OCS and onshore Federal and Indian lands, and distribute those revenues.

Moreover, in working to meet its responsibilities, the **Offshore Minerals Management Program** administers the OCS competitive leasing program and oversees the safe and environmentally sound exploration and production of our Nation's offshore natural gas, oil and other mineral resources. The MMS **Royalty Management Program** meets its responsibilities by ensuring the efficient, timely and accurate collection and disbursement of revenue from mineral leasing and production due to Indian tribes and allottees, States and the U.S. Treasury.

The MMS strives to fulfill its responsibilities through the general guiding principles of: (1) being responsive to the public's concerns and interests by maintaining a dialogue with all potentially affected parties and (2) carrying out its programs with an emphasis on working to enhance the quality of life for all Americans by lending MMS assistance and expertise to economic development and environmental protection.

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Energy Alternatives and the Environment

I. Introduction

This paper considers energy alternatives to the proposed action in the “Outer Continental Shelf Oil and Gas Leasing Program for 1997 to 2002" (MMS 1996) (5-Year Program). The Minerals Management Service (MMS) is concerned with energy alternatives for three major reasons:

1. The National Environmental Policy Act requires consideration of a No Action Alternative to the proposed action when preparing an environmental impact statement (EIS). Examining other energy sources is an important aspect of the No Action Alternative for the 5-Year Program.

2. Those commenting on previous 5-Year Programs have requested consideration of energy alternatives or have suggested that specific energy alternatives are superior to the proposed program.

3. MMS believes that consideration of alternatives is an important basis for the ultimate decision about the proposed schedule.

The alternatives considered in this paper extend beyond the Outer Continental Shelf (OCS) and even beyond the span of responsibility of the Secretary of the Interior. However, the paper only considers environmental impacts associated with production and transportation of the alternatives. This limitation is chosen in order to keep the discussion parallel to that in the EIS accompanying the 5-Year Program. The rationale for this decision is that OCS oil and natural gas are mixed with similar onshore product and become indistinguishable prior to refining, transport, and final consumption. Any environmental analysis beyond the mixing point would become an analysis of the entire oil and natural gas industry which is an insupportable expansion of the boundary of OCS activities. An exception to this bounding occurs in cases where compliance with environmental regulations affects the cost structure of an energy alternative. In those cases, environmental impacts in final use may be mentioned because they influence the financial viability of the alternative.

Understanding alternatives to oil and natural gas requires an appreciation for the complex nature of these materials. Both oil and natural gas are mixtures of many chemical compounds with different mixtures characterizing different geologic deposits. Crude oil, when processed through an atmospheric distillation column, or natural gas, when processed through a separation plant, break into numerous, identifiable categories of organic chemicals, each with a large number of sub-categories.

Natural gas, which is mostly methane, often includes heavier hydrocarbon compounds called

"Natural Gas Liquids" or "NGL's." The majority of NGL's are stripped from the "wet" gas at natural gas processing plants. A subset of the NGL's, propane and butane, which remain gaseous at ambient pressures and temperatures, are also found in crude oil. Under pressure they form liquids and are known as liquefied petroleum gases (LPG's). Some of the heavy NGL's, which are liquid at ambient temperatures and pressures and also found in crude oil, are referred to as "natural gasoline" or "pentanes plus" and are classified as lease condensate. Despite NGL's association with natural gas production, this paper will follow the standard convention that combines NGL data with crude oil data.

An investigation into alternatives to OCS natural gas and oil needs to be built on the following types of information:

- the uses of natural gas and oil
- the alternatives that can be used to fulfill those uses
- the circumstances under which alternatives might be adopted
- the financial implications and environmental effects of adopting the alternatives

This paper is organized around these types of information with emphasis on society's end uses for products derived from natural gas and oil and the alternatives to those end uses. This approach encourages consideration of a broad range of alternatives. It also opens up the possibility to identify creative solutions to the substitution question.

Products made from natural gas and oil permeate virtually every aspect of life in a modern industrial society. The next two sections identify the uses of these products.

II Uses for Oil and NGL's

Society's end uses for oil and NGL's (referred to as oil for the remainder of this discussion) can be categorized into uses for:

- Transportation vehicles and as fuel for similar machine engines
- Industrial heat, steam, and cogeneration
- Residential and commercial heat, hot water, etc.
- Electricity generation
- Non-energy uses

Table 1 provides statistics on quantities and percentages of oil-based products used in each energy category or sector. As the table shows, oil provides about 36 percent of our energy on a Btu basis. It dominates transportation to such an extent that it can be said that U.S. transportation runs on oil. Oil is an important, but not dominant, source of energy to industry. It makes a modest contribution to the residential and commercial sector and only a minor contribution in electricity generation.

Table 1. Oil Consumption by End-Use Sector.

End-Use Sector	Transpor-tation	Industrial	Residential and Commercial	Electricity Generation	Total
1994 Consumption (Quadrillion Btu)	22.714	8.813	2.239	.968	34.734
The sector as a percentage of total 1994 oil consumption	65.39%	25.37%	6.45%	2.79%	100.00%
Oil as a percentage of the sector (1994)	97.14%	36.26%	13.18%	3.13%	36.35%

Source: U.S. Department of Energy, Energy Information Administration. *Monthly Energy Review: June 1995.* Staff Report DOE/EIA-0035(95/06).

Another way to categorize oil use is by the products into which the oil is refined and then sold. Table 2 shows statistics on sales of major oil refinery products. Gasoline constitutes almost 55 percent of the total sales volume of oil-based refinery products, diesel fuel makes up almost 15 percent, and jet fuel almost 10 percent. It is easy to see that fuels used primarily in transportation constitute most of the volume of refinery products.

II.A Transportation Vehicles

By far the largest and most important use for oil products in the U.S. economy is as transportation fuel. Oil products fuel a majority of vehicles in every major transportation mode.

II.A.1 Gasoline Powered Vehicles and Engines

The almighty automobile is the dominant icon of the American way of life. In a typical year Americans drive over a trillion miles and use about 120 billion gallons of gasoline going about their work and play. The flexibility, ease of operation and maintenance, performance, and relatively clean running of gasoline engines make them the choice for the vast majority of automobile owners. In addition to cars, gasoline is used to fuel:

- Light trucks and buses
- Small Boats
- Reciprocating engine aircraft
- Light farm tractors

- Small engines for many industrial, commercial, agricultural, and residential uses

Table 2. Sales of Refinery Products.

Refinery Product	**Sales Volume (12/94) (1000 gal/day)**	**Percent of Total**
Gasoline	334,725.5	54.22%
Jet Fuel	56,867.3	9.22%
Propane (Consumer Grade)	46,122.4	7.47%
Kerosene & No. 1 Distillate	10,259.3	1.66%
No. 2 Diesel Fuel	89,260.1	14.46%
No.2 & No.4 Fuel Oil	48,089.6	7.79%
Residual Fuel Oil	31,993.7	5.18%
Total	617317.9	100.00%

Source: U.S. Department of Energy, Energy Information Administration. *Petroleum Marketing Monthly: March 1995*. Staff Report DOE/EIA-0380(95/03).

II.A.2 Diesel Powered Vehicles and Machinery

Diesel engines are the work horses of the industrial world. Their efficiency and reliability make them the choice for firms and individuals with heavy duty applications where long-run costs are an important consideration. In addition to the ubiquitous diesel truck, diesels are used to power:

- Cars
- Buses
- Trains
- Boats
- Machinery

II.A.3 Jet Fuel Powered Aircraft

Almost all large passenger airplanes, most large cargo aircraft, and many smaller planes and helicopters are powered by jet engines or use turbo jets for their propulsion. Jet airplanes are almost always faster than their propeller-powered counterparts and turbojet planes and helicopters are usually faster than reciprocating engine models. Because much of the point of flight is to travel faster, jet planes dominate the most important niches in the aviation industry.

Jet fuel lies between gasoline and diesel fuel or fuel oil in volatility. It comes in 2 grades; however, well over 90 percent of jet fuel sold in the U.S. is of the kerosene type.

II.A.4 Steam Powered Ships

Ships generally use relatively crude steam boilers for their power. These boilers can be powered by virtually any combustible material although virtually all modern ships use oil-based products for their fuel. In the recent past ships used some of the lowest grades of residual fuel oil and the heaviest distillates. More recently air pollution restrictions while they are in port have led shipping companies to switch to less polluting medium distillates.

II.A.5 Propane-Powered Industrial and Commercial Vehicles

Industrial and commercial establishments employ LPG (usually referred to as "propane") powered small vehicles and machinery such as fork lifts primarily for off-road applications. LPG is usually chosen because of the generally lower maintenance costs associated with this fuel and the better performance compared to similar electric machinery. Even though LPG is primarily used in off-road applications, LPG powered vehicles are the largest class of alternative-fueled vehicles on United States highways (EIA 1996).

II.B Industrial Sector Uses

Next to the transportation sector, industry uses more oil products than other sectors. However, oil only provides a little over a fourth of industrial energy. This percentage has been relatively stable for many years.

II.B.1 Industrial Process Heat and Steam

Heat and steam perform a vast array of tasks for industry from melting metals to driving chemical processes to aiding the bonding of materials. Oil competes with other energy sources for this role and usually wins out in situations where coal produces unacceptable levels of air pollution, natural gas is unavailable in adequate quantities, or capital equipment was originally designed for oil and replacement is too expensive. Steam still powers some machinery, but most machines are now either powered by electric motors or diesel engines (which were covered along with diesel transportation equipment).

II.B.2 Air Conditioning and Drying

Air conditioning includes both heating and cooling. Oil products are used not only for raising the comfort level of industrial buildings, but also to create the right air temperature and humidity conditions to maximize the effectiveness of various processes or to minimize maintenance costs. Drying is a response to the many industrial processes involving wet materials. Oil successfully competes for industrial air conditioning and drying in many of the same situations as for industrial process heat and steam.

II.B.3 Cogeneration

Cogeneration is the process of using excess or exhaust steam from an industrial process for generating electricity. The Public Utility Regulatory Policies Act of 1978 (PURPA) requires electric utilities to purchase available power from willing sellers at reasonable prices. Since the passage of PURPA, a large percentage of the potentially viable cogeneration sites have gone into service. Cogeneration now constitutes almost ten percent of U.S. electricity generation and the Department of Energy expects cogeneration to maintain this percentage through the year 2000 (EIA 1996b).

II.C Residential and Commercial Sector Uses

The residential and commercial sectors use products made from oil for air conditioning (primarily heating), heating water, and running appliances (in locations not served by electricity). Natural gas and electricity dominate these sectors. Oil products compete best where natural gas is unavailable and the climate is sufficiently cold that electric heat pumps are inefficient. A broad range of oil products serve the residential and commercial sectors from LPG (propane) through kerosene to fuel oil. Choice depends mostly on local availability and already-installed equipment.

II.D Electricity Generation

II.D.1 Steam Boilers

Most electricity is generated by heating water to the boiling point and directing the expanded volume of steam through a turbine. The rotating shaft of the turbine connects to the shaft of a generator which produces electricity. Virtually any fuel can be used to fire the steam boilers. Oil-based products, even relatively cheap residual fuel, is usually more expensive per kilowatt of electricity produced than other fuels such as natural gas and coal. Oil-fired steam boilers tend to be used in situations where conversion to natural gas is impractical due to unavailability of gas or where it would be too expensive to convert.

II.D.2 Diesel Generators

Diesel engines can also be used to turn the shaft of a generator to produce electricity. Diesels are usually only used in remote sites where the electricity demand is too small to justify the expense of installing a steam boiler and transportation of diesel fuel is relatively inexpensive.

II.E Non-energy Uses

II.E.1 Chemical Feedstock

The chemical industry converts NGL's and oil refinery products into a vast array of goods for industry and final consumers. Plastics, artificial fibers, paints and preservatives, agricultural chemicals, and many pharmaceuticals are all made primarily from NGL's and oil refinery products. Although our economy consumes large quantities of these products, the amount of oil going into them is much less than that which goes into energy uses, especially transportation.

II.E.2 Solvents, Lubricants, Asphalts, and Waxes

Several other groups of chemicals are made from oil and LPG's, but retain much of their original characteristics even after chemical conversion. These are solvents, lubricants, asphalts, and waxes. The properties of the various types of LPG and oil used as feedstocks are enhanced in the chemical conversion process but retain much of their original nature.

III Uses for Natural Gas

As table 3 shows, the industrial sector is the number one consumer of natural gas followed closely by the residential and commercial sectors. Electricity generation uses less than half as much gas as the preceding sectors; however, it is the fastest growing major use of natural gas. The figure shown for transportation refers only to the use of natural gas in pipeline transportation.

Table 3. Natural Gas Consumption by End-Use Sector.

End-Use Sector	Industrial	Residential and Commercial	Electricity Generation	Transpor-tation	Total
1994 Consumption (Quadrillion Btu)	9.545	8.036	3.053	.655	21.289
The sector as a percentage of total 1994 gas consumption	44.84%	37.75%	14.34%	3.08%	100.00%
Gas as a percentage of the sector (1994)	39.27%	47.32%	9.89%	2.80%	22.28%

Source: U.S. Department of Energy, Energy Information Administration. *Monthly Energy Review: June 1995.* Staff Report DOE/EIA-0035(95/06).

III.A Industrial Sector Uses

Industry uses more natural gas on a Btu basis than any other source of energy. The percentage of energy industry derives from natural gas has risen every year from 1986 to 1993, surpassing oil-derived products in 1987. Natural gas is attractive to industry for three major reasons:

1. It is relatively inexpensive on a Btu basis compared to oil-based products and electricity although it is more expensive than coal.

2. Burning natural gas produces less air pollution, including greenhouse gases, than any other fossil fuels, this allows industry to use natural gas burning technology without expensive pollution control equipment that might be required for other energy sources.

3. The cleaner burning and handling character of natural gas tends to keep maintenance costs low.

Further adoption of natural gas is limited primarily by the unavailability of secure supplies or by equipment designed for other energy sources which has not yet reached the replacement point.

Industry uses natural gas for the same purposes as it uses oil-based fuels:

- Industrial Process Heat and Steam
- Air Conditioning and Drying
- Cogeneration

These industrial processes use much the same technology for both natural gas and oil-based fuels. Differences derive mostly from the gaseous nature of natural gas versus the liquid nature of most oil-based products. Of special note is that over 60 percent of United States cogeneration is fueled with natural gas (EIA 1996b).

III.B Residential and Commercial Sector Uses

Natural gas performs much the same role in the residential and commercial sectors as oil: to condition air (primarily to heat it), to heat water, and to run appliances in locations not served by electricity. Natural gas and electricity dominate these sectors. The residential and commercial sectors favor natural gas because of its low cost and low maintenance. Lack of access or the expense of access to gas pipelines limits the further penetration of natural gas into these sectors.

III.C Electricity Generation

The natural gas industry considers electricity generation to be its growth sector. Although electric utilities are not adding much generating capacity these days, gas will fire most new power plants either under construction or in the planning stages.

III.C.1 Turbines

Much new and planned electricity generating capacity consists of gas turbines. Gas turbines operate by directing the hot gases from burning natural gas into a turbine. As in a steam boiler, the rotating shaft of the turbine connects to the shaft of a generator which produces electricity.

Electric utilities have to deal with vast swings in the demand for their power. So-called peaks in demand occur on summer afternoons when air conditioning reaches its maximum and on winter evenings when electric ranges and other appliances add their draw to heating. Peaking power is the most expensive power for utilities to produce. Gas turbines, because of their very rapid fire-up capability, are the equipment of choice for peaking in the absence of or to augment hydroelectric and pump storage capacity.

In addition, their low initial capital cost, relatively low maintenance, and fairly low fuel cost makes them highly competitive with coal-fired plants, which require expensive pollution control technology.

III.C.2 Steam Boilers

Gas-fired steam boilers are very similar to oil-fired models; indeed, some boilers are designed to use either fuel with only minor adjustments. Most duel-fuel boilers and most boilers that can be inexpensively converted to gas already use gas because of its lower cost on a Btu basis, reduced air pollution, and less expensive maintenance.

III.C.3 Combined Cycle

Combined cycle plants first use natural gas to fire gas turbines, then they use the hot gases from the turbine exhaust to create steam which is used to generate electricity in the same way as in normal cycle steam generation. The cost of electricity generated using combined cycle technology compares favorably with that produced using other fuels in conventional plants. The possibility also exists to use the hot water remaining when the steam condenses in a cogeneration mode.

III.D Transportation

The 1994 transportation sector consumption of natural gas reported in table 3 consists entirely of gas used to power the pumps and other machinery that moves natural gas across the country via pipelines. Any natural gas used in motor vehicles is reported in the residential and commercial sector because almost all the natural gas vehicles in service in the United

States are fleet vehicles operated by commercial establishments. Vehicular use of natural gas is growing rapidly; however, it accounts for only a small percentage of the highway fuel used in the United States.

III.E Non-energy Uses

Natural gas, primarily methane, is also used as a chemical feedstock. Among the products made from natural gas are chemicals like methanol, ammonia, and formaldehyde which are converted into final products like fertilizer, detergents, and glues.

IV. The No Action Alternative

The National Environmental Policy Act requires consideration of a No Action Alternative to every major Federal action significantly affecting the environment. In the case of the 5-Year Program, no action means that the MMS would hold no OCS oil and gas lease sales during the 5-year period covered by the Program. As a result of holding no lease sales, rights to oil and natural gas resources on the OCS would not be transferred to production firms and the oil and natural gas that would have been produced as a result of sales over that 5-year period would not be available to consumers. This section reports the results of an investigation into the most likely response of oil and natural gas markets to a curtailment of their supplies from the OCS and the resulting environmental impacts. Under these assumptions, markets would have to respond to a reduction in supply equal to the anticipated production from the 5-Year Program. Note that in 1995 almost 70 percent of OCS production on a Btu basis consisted of natural gas. The other 30 plus percent was oil and NGL's.

IV.A Methodology

The MMS employs the market simulation model to evaluate the impact of decreased OCS production resulting from no action. The market simulation model estimates changes in quantities of alternatives to OCS natural gas and oil traded in domestic markets. This same model, which includes oil and gas submodels, also performs other analysis used in the development of the 5-Year Program. A more detailed description of the market simulation model can be found in a companion paper to this one (King 1996).

IV.B Market Response to a Reduction in OCS Production

The MMS ran the market simulation model for cases representing all program alternatives with both most likely and high price assumptions. The purpose of these runs was to demonstrate the response of oil and gas markets to a reduction in OCS production under a variety of circumstances. The most likely prices are $18 per barrel of oil and $2.11 per mcf of gas. The high price case is based on prices of $30 per barrel of oil and $3.52 per mcf of gas. The results for the different program alternatives are virtually identical. Only modest differences crop up between most likely and high priced cases.

IV.B.1 Results for Oil

Table 4 shows the most important results of a run comparing the proposed action to no action under most likely and high price assumptions. The percentage estimates are the most interesting and useful numbers in the table. They imply that for each barrel of OCS oil not produced:

- onshore U.S. oil production will increase by about 0.04 barrels
- U.S. oil imports will increase by about 0.88 barrels
- Conservation will account for a decline in U.S. oil consumption of about 0.05 barrels.
- Switching to gas will amount to the equivalent of about 0.03 barrels.

Table 4. Results of the No Action Alternative.

Sector	% of OCS Production	Quantity Involved	
		Most Likely	High
Oil			
OCS Production (BBO)	-100%	-3.27	-8.04
Onshore Production (BBO)	4%	0.13	0.32
Imports (BBO)	88%	2.88	7.08
Conservation (BBOE)	5%	.16	0.40
Switch to Gas (BBOE)	3%	.10	0.24
Gas			
OCS Production (TCFG)	-100%	-11.16	-32.81
Onshore Production (TCFG)	41%	4.58	13.45
Imports (TCFG)	12%	1.34	3.94
Conservation (TCFGE)	14%	1.56	4.59
Switch to Oil (TCFGE/BBOE)	33%	3.68/0.65	10.83/1.93
Induced Oil Imports (BBO)	NA	0.57	1.70

BBO = billion barrels of oil, BBOE = the Btu equivalent of billion barrels of oil, TCFG = trillion cubic feet of natural gas, TCFGE = the Btu equivalent of trillion cubic feet of natural gas.

In table 4, oil production lost from no action during the period of the 5-Year Program is replaced by onshore production, imports, conservation, and switching to gas. In absolute terms expectations are for:

- onshore production to make up 13 million of the 3.27 billion barrels lost through no action at the most likely price and 32 million of the 8.04 billion barrels of OCS production lost at the high price,
- imports to account for 2.88 billion barrels at the most likely price and 7.08 billion barrels at the high price,
- conservation to total the equivalent of 16 million barrels at the most likely price and 40 million at the high price, and
- switching to gas the equivalent of 10 million barrels at the most likely price and 24 million at the high price. (The market simulation model deals with the oil and gas markets in isolation. In reality, if OCS production were curtailed, less gas would be available leading to more imported oil, conservation, and domestic onshore production than the model shows.)

All these amounts would substitute for the 3.27 billion barrels of oil lost through no action at the most likely price and 8.04 billion barrels at the high price. The distribution of conservation and switching to gas by sector depends on the amount of consumption in each sector and the price elasticities of demand in each sector. Transportation is projected to account for 69 percent and industrial consumption 26 percent of U.S. oil use in the year 2000. Residential and commercial consumption are projected to account for only 6 percent of 2000 U.S. oil use (EIA 1996b).

Other forms of energy cannot readily substitute for most of this oil in the near term. In the U.S. transportation sector, a consumption decline probably would involve a reduction in miles traveled or the purchase of more fuel efficient cars. Most energy projections show very little alternative fuel, such as methanol, entering the transportation sector for many years (EIA 1996b). Significant additional fuel substitution in response to the relatively small price increase implied by the model would be unlikely. In addition to the modest price increase associated with these scenarios, the costs of replacing the present transportation fuel infrastructure further hinders efforts to extend the use of alternative transportation fuels.

In the industrial sector most uses for which there exists a ready substitute have already converted to the substitute. Many industrial uses such as for products like asphalt and lube oils have few comparable substitutes. Oil use in the residential and commercial sectors is forecast to occur principally at locations without access to natural gas, so little fuel substitution can be expected.

The only areas where significant substitution is likely is for industrial heat and steam and electricity generation. The degree of substitution in these sectors depends on whether oil is competing directly with gas for market share. Currently, natural gas and oil do not compete in the boiler market because gas is significantly cheaper. In the fairly near future, gas prices could rise to the level of oil prices in these sectors and fuel switching could then occur.

IV.B.2 Results for Natural Gas

Table 4 also reveals that for each unit of OCS gas not produced because of no action, MMS anticipates the following results:

- U.S. onshore gas production will increase by about 0.41 units
- imports will increase by about 0.12 units
- conservation will account for about 0.14 units
- switching to oil will amount to the equivalent of about 0.33 units

In absolute terms at the most likely price this amounts to:

- 4.58 trillion cubic feet of onshore gas
- 1.34 trillion cubic feet of gas imports (mostly from Canada)
- conservation equivalent to 1.56 trillion cubic feet of gas
- switching to oil equivalent to 3.68 trillion cubic feet of gas

substituting for the 11.16 trillion cubic feet of OCS natural gas lost through no action.

In absolute terms at the high price this amounts to:

- 13.45 trillion cubic feet of onshore gas
- 3.94 trillion cubic feet of gas imports (mostly from Canada)
- conservation equivalent to 4.59 trillion cubic feet of gas
- switching to oil equivalent to 10.83 trillion cubic feet of gas

substituting for the 32.81 trillion cubic feet of OCS natural gas lost through no action.

Of the reduced consumption of natural gas at the most likely price, the equivalent of about 3.68 trillion cubic feet of gas would consist of switching to oil. This means that an additional 0.65 billion barrels of oil would clear the market. Assuming that imports constitute 88 percent of any additional oil traded in the U.S. market, then this adds another .57 billion barrels of oil to imports. Thus, as a result of no action, an additional 3.45 billion barrels of oil would have to be imported by the U.S. The corresponding import estimate for the high price case is 8.78 billion barrels of oil. Table 5 shows these calculations in detail.

IV.C Environmental Impacts from the Market Response to a Reduction in OCS Production

IV.C.1 Onshore Oil and Gas Production

Onshore oil and gas production often occur together from the same wells; furthermore, the impacts from efforts to recover the two resources are almost identical even in those cases where production from a given location is entirely oil or entirely gas. Onshore oil and gas production has notable negative impacts on surface water, groundwater, and wildlife. Onshore oil and gas production can also be expected to cause negative impacts on soils, air pollution, vegetation, noise, and odor.

Surface water could incur increased turbidity, salinity, and sedimentation caused by runoff from road, drilling pad, and pipeline construction. Other sources of water pollution include discharges of drilling muds, other toxic chemicals, and engine fuels and lubricants. Although holding ponds or reserve pits for produced waters and other process waste are required to retain any environmentally hazardous substances, spills of such materials into surface waters are a risk.

Table 5. Calculations Leading to Total Oil Imports Resulting from No Action.

Most Likely Price	High Price
11.16 TCFG (OCS gas production lost through no action) X .33 (the portion of lost gas switched to oil) = 3.68 TCFGE (amount of lost gas switched to oil) ÷ 5.62 Mcf per BOE (conversion factor) = .65 BOE (amount of oil switched to from lost gas) X .88 (the portion of lost oil replaced by imports) = .57 BBO (amount of oil imports replacing lost gas) + 2.88 BBO (amount of oil imports replacing lost oil) = 3.45 BBO (total oil imports replacing oil and gas lost through no action at the most likely price)	32.81 TCFG (OCS gas production lost through no action) X .33 (the portion of lost gas switched to oil) = 10.83 TCFGE (amount of lost gas switched to oil) ÷ 5.62 Mcf per BOE (conversion factor) = 1.93 BOE (amount of oil switched to from lost gas) X .88 (the portion of lost oil replaced by imports) = 1.70 BBO (amount of oil imports replacing lost gas) + 7.08 BBO (amount of oil imports replacing lost oil) = 8.78 BBO (total oil imports replacing oil and gas lost through no action at the high price)

TCFG = trillion cubic feet of natural gas, TCFGE = the Btu equivalent of trillion cubic feet of natural gas, BOE = the Btu equivalent of barrel of oil, BBO = billion barrels of oil.

Groundwater can be contaminated from puncture of the aquifer or from leaching down from improperly sealed surface holding ponds or overflow of those ponds onto permeable surfaces. In many areas, sufficient interchange occurs between surface and groundwater sources that pollution of one leads to the contamination of the other.

For the most part, surface disturbance from oil and gas development is sufficiently limited that it causes relatively minor negative impacts on wildlife. A large portion of the negative impact on wildlife comes through water pollution and the impacts on wildlife living in or drinking from a water supply contaminated by oil and gas extraction activities. However, holding ponds can pose a significant threat to birds, especially waterfowl. Improperly safeguarded holding ponds can prove to be attractive to waterfowl and other birds looking for a safe resting and feeding location. Birds landing on these ponds may drown when the action of solvents in the pond material destroys the buoyancy of the birds' feathers.

Soil and vegetative disturbance is mostly a result of construction activities. However, soils can become contaminated and vegetation killed by spills of herbicidal chemicals.

Air pollution, noise, and odors are a consequence of the production process. Local standards usually control these impacts, but additional oil and gas production can increase cumulative levels of these forms of pollution.

IV.C.2 Imports

Significant environmental impacts associated with expanded importation of oil include:

- the generation of greenhouse gases and regulated air pollutants from both transport and dockside activities (emissions of NO_x, SO_x, and VOCs having an impact on acid rain, tropospheric ozone formation, and stratospheric ozone depletion)
- degradation of water quality in the instances of oil spills from either accidental or intentional discharges or tanker casualties
- possible destruction of flora and fauna and recreational and scenic land and water areas in the instance of oil spills
- public fear of the increased likelihood of oil spills.

Of these, the most significant are likely to be the impacts associated with oil spills. Table 6 shows by region the estimated additional spills greater than 1000 barrels associated with the no action alternative, along with their probabilities.

The environmental impacts from oil spills are well documented in the EIS for the 5-Year Program. While it is uncertain where the spills associated with additional imports will occur, the impacts will be similar to those associated with OCS production except that the risk of very large spills is enhanced by the use of large tankers to import oil. Compared to OCS production, tankers increase the probability that more oil will reach beaches and other shore areas. In addition, it is more likely that environmental damage will occur in valuable areas near population centers surrounding ports where imported oil is landed.

This paper does not address environmental impacts outside the United States. In the case of imported oil, negative environmental impacts in producing countries and in countries along trade routes can be significant.

IV.C.3 Conservation

As shown in table 4, the price increase induced by the no action alternative will lead people to conserve about 5 percent of expected oil consumption and about 14 percent of expected natural gas consumption. This conservation is composed of two major components:

Table 6. No Action Alternative - Large Oil Spill Estimates

Variables	Gulf of Mexico	Alaska	Pacific	Atlantic
Additional Imports (BBO)	0.72 - 2.36	0.12 - 0.22	2.04 - 4.50	-
# of spills $\geq$ 1000 bbl	0.44 - 1.43	0.07 - 0.13	1.23 - 2.72	-
Probability of 1 or more spills $\geq$ 1000 bbl	36% - 76%	7% - 12%	71% - 93%	-
Imports Induced by Switching from Gas to Oil (BBO)	0.57 - 1.70	-	-	-
# of spills $\geq$ 1000 bbl	0.34 - 1.03	-	-	-
Probability of 1 or more spills $\geq$ 1000 bbl	29% - 64%	-	-	-
Total Imports (BBO)	1.29 - 4.06	0.12 - 0.22	2.04 - 4.50	-
# of spills $\geq$ 1000 bbl	0.78 - 2.46	0.07 - 0.13	1.23 - 2.72	-
Probability of 1 or more spills $\geq$ 1000 bbl	54% - 91%	7% - 12%	71% - 93%	-

- substituting energy saving technology, often embodied in new capital equipment, for energy resources (for example, adding to home insulation); and
- consuming less of an energy using service (for example, turning down the thermostat in an office during the winter).

This paper discusses the environmental impacts from oil and gas conservation in sections VI and VII, respectively.

IV.C.4 Fuel Switching

Table 4 shows people switching about 3 percent of their consumption from oil to gas and about 33 percent from gas to oil. This seemingly anomalous result is a function of the two submodels used to estimate the oil and gas market responses. To keep the analysis simple, the two submodels account for the price change in their market in isolation from the other market.

In reality, there would probably be no switching from oil to gas. Because the OCS produces a larger proportion of U.S. gas than oil and because it is much easier to increase oil imports than gas imports, the price of gas would rise relative to the price of oil and people would switch to oil. This would shift the demand for oil at the same time the supply was being restricted. The major source to satisfy this increased demand would be imports which would add to the imports induced by the initial oil supply decrease.

V. Government Imposition of Energy Alternatives

In the U.S. economy most decisions about the allocation of resources are made by market forces. However, government sometimes chooses to override market decisions in order to change the economy's energy mix. This section will investigate specific forms of energy government might choose as substitutes for OCS natural gas and oil and some of the consequences of those choices.

Even if leasing on the OCS proceeds, government can choose policies having the effect of imposing various energy alternatives on society. These policies may be chosen to:

- minimize reliance on imports, such as oil, from unstable regions
- encourage the use of a politically favored fuel, such as ethanol
- reduce air pollution, such as by mandating electric vehicles
- conserve energy.

Government can use a variety of policy tools to encourage or force the adoption of a desired energy mix. Among these are:

- taxes
- subsidies
- performance standards.

V.A Taxes to Achieve a Desired Energy Mix

Government can impose either broad-based or narrowly-focused energy taxes. A broad-based energy tax would tax all or a broad spectrum of energy alternatives. An example which has been discussed at considerable length recently is the carbon tax. The carbon tax would impose a levy on all hydrocarbon materials used as sources of energy in proportion to the amount of carbon the material contains. The carbon tax is aimed at controlling the sources of greenhouse gases that are thought to contribute to global warming. The increased cost of fuels containing carbon would encourage consumers to switch to non-carbon sources of energy such as wind power, solar energy, hydroelectric, and nuclear energy. It would also encourage conservation both through the substitution of capital for energy and through reduced use. However, a recent effort to impose a carbon tax in the United States was abandoned due to the considerable opposition the proposal faced and the practical difficulties entailed in implementation.

Narrowly focused energy taxes include the taxes imposed by national and state governments on vehicle fuels. Although these fuel taxes have the primary purpose of raising money to pay for highway, road, and bridge construction and maintenance, they also have the effects of discouraging people from using road transportation and substituting rail, plane, or a transportation mode significantly more fuel efficient than the private automobile, such as buses.

V.B Subsidies for Energy Alternatives

Many governments subsidize favored energy sources, actions usually justified as a temporary aid to start an infant industry. Recent examples in the U.S. are tax rebates for ethanol used as a gasoline additive and the subsidy extended to coal bed methane extraction for addition to the natural gas system. Subsidies that reward production of an energy product serve to reduce that product's unit costs and thus lower the supply curve for the product leading to increased use and enhanced profits for producers.

Subsidies can also take the form of grants to consumers. Home heating subsidies for the poor in the U.S. are an example of this approach. Consumer energy subsidies tend to raise the effective demand curves for the fuels involved leading to greater sales and profits. This type of subsidy tends to apply to a range of different energy sources any of which could be used to perform the function being supported such as heating homes in winter. Although home heating subsidies tend to increase fuel use, subsidies for things like insulation and weatherization could be used to encourage fuel conservation.

V.C Energy Performance Standards and Regulations

Energy performance standards and the regulations developed to implement them are one of the cornerstones of U.S. energy policy. The best known set of energy performance standards are the CAFE standards that set the average fleet vehicle miles per gallon of gas that each automobile manufacturer must meet with the set (fleet) of vehicles the manufacturer produces in a year.

VI. Alternatives to Oil and NGL's and Their Environmental Impacts

Primary alternatives to OCS oil are imported oil and oil from onshore production. In addition to these primary alternatives, other materials and forms of energy can be substituted for oil to provide the services consumers demand. However, only five basic ways exist to replace the oil society decides not to obtain from the OCS: import, produce onshore, switch fuel, substitute oil saving technology, or accept less service. The total number of specific alternatives fitting within these broad categories appears almost endless. Nevertheless, the basic approaches to replacement are limited. The same point holds true for natural gas.

Importation and onshore production are covered in section IV.C. This section will review the other potential substitutes for OCS oil. The discussion will cover the potential future market and the environmental impacts from the production and transportation of the original energy resource for each specific energy alternative.

VI.A Transportation Vehicle Fuel

Table 1 shows the transportation sector to be by far the largest user of oil and oil being the overwhelmingly dominant transportation fuel in the U.S. economy. Thus, the transportation sector is the first place to look for ways to replace oil. In the words of the *National Energy Strategy* (DOE 1991), "The transportation sector offers the best available opportunity to reduce U.S. dependence on oil, improve the quality of air in metropolitan areas, and spur the development and use of new, more efficient, environmentally superior vehicle and fuel technology."

Oil can be replaced by switching to other fuels, adopting more efficient vehicles, implementing more efficient transportation systems, and accepting less motorized transportation. The latter three of these alternatives are examples of conservation.

VI.A.1 Alternative Fuels

Table 7 lists the consumption of alternative fuels and the number of alternative-fueled vehicles in the United States for 1995 estimated by the U.S. Department of Energy, Energy Information Administration (EIA). The largest number of these vehicles are powered by LPG. This is an oil product so it is not relevant to this discussion.

Clearly the most popular non-oil-based alternative fuels are compressed natural gas and methanol. Other fuels may have future potential, but they are not viable presences yet.

VI.A.1.a Natural Gas

Two forms of natural gas can be utilized as transportation vehicle fuel, Compressed Natural Gas (CNG) and Liquefied Natural Gas (LNG). LNG applications are limited to a few heavy duty trucks and, primarily, passenger buses in three large programs (Houston, Seattle, and Los Angeles). CNG's easier and cheaper conversion and handling give it the lead in current applications to transportation. According to EIA, the growth in the number of CNG vehicles between 1992 and 1996 is expected to exceed that of all other types of alternative fuels. This growth is explained by Montgomery and Sweeney (1991),

Table 7. Estimated Consumption of Vehicle Fuels and Number of Alternative-Fueled Vehicles in the United States, 1995.

Fuel	**Consumption** (Thousand Gasoline-Equivalent Gallons)	**Alternate-Fueled Vehicles**
LPG	259,940	272,000
Compressed Natural Gas (CNG)	43,631	65,849
Liquefied Natural Gas (LNG)	3,110	482
Methanol, 85 Percent (M85)	2,372	20,170
Methanol, Neat (M100)	3,050	413
Ethanol, 85 Percent (E85)	105	894
Ethanol, 95 Percent (E95)	140	32
Electricity	571	2,350
Non-LPG Alternative Fuel Subtotal	59,979	90,190
Gasoline	115,809,000	
Diesel	26,739,580	
Total	142,861,499	

Source: U.S. Department of Energy, Energy Information Administration. *Alternatives to Traditional Transportation Fuels, 1994, Volume 1.* DOE/EIA-0585(94)/1, February 1996.

> Compressed natural gas is now the alternative fuel with the lowest net cost, considering all factors, and appears to be finding its way into the market under current policies. Its role may be greatest in fleet operations, especially those involving large vehicles, where central refueling and some loss in vehicle space is not important, and where the low cost of natural gas fuel is important.

EIA (1996) adds that other factors promoting the growth of CNG are “support from natural gas utilities, relatively greater availability of vehicles and fuels compared to most other alternative fuels, and continued public and private sector enthusiasm for the fuel." The cause of problems with CNG fuel cylinders has apparently been identified and eliminated from recent applications.

The natural gas to be utilized as a transportation fuel in the form of CNG can be supplied from OCS, domestic onshore, pipeline imports from Canada, or imported LNG sources. Environmental impacts from domestic OCS production are covered in the 5-Year EIS. Domestic onshore production is covered in section IV.C.1 of this paper.

Additional pipeline imports from Canada would require additional pipelines. Associated construction would lead to temporary increases in water pollution from unstabilized construction sites and spills of construction related fuels and other chemicals.

LNG imports introduce a new form of environmental impact. In addition to the risk of fuel spills from LNG ships, there is a slight risk of an LNG leak. Because LNG is super cold, as it vaporizes the cold vapors gather close to the ground where they smother any animal inhabitants. If a large quantity of the vapors could be ignited, they would produce a violent explosion. Fortunately, the risk of such an occurrence is very remote.

VI.A.1.b Methanol

Two forms of methanol find application as transportation fuels: M85, which is 85 percent methanol and 15 percent gasoline, and M100, which is pure (neat) methanol. M100 use has apparently peaked. Because of the poor performance and maintenance record it has compiled, little additional M100 use is expected in the future (EIA 1996).

Adoption of M85 as a transportation fuel seems to be governed by the cost of methanol. Four variables go into the price of methanol as a transportation fuel: 1) the price of natural gas because virtually all commercial methanol is made from natural gas, 2) the cost of building the very large conversion plants needed to capture economies of scale, 3) the cost of developing the necessary new distribution system, and 4) the demand for methanol for other purposes. Methanol is a raw material in the creation of methyl tertiary butyl ether (MTBE). MTBE is a constituent of reformulated gasoline. Recent demand for reformulated gasoline has driven up the price of methanol and it is still uncertain where the price will eventually settle.

Conversion of gasoline and diesel powered vehicles to methanol is relatively inexpensive; however, dual powered vehicles capable of using either gasoline and methanol or diesel and methanol seem to encounter technical problems. The process of conversion from gasoline to methanol entails the development of a new fuel distribution network. The implication of this requirement is that a major conversion effort must be launched to make this alternative viable. However, the effort need not be nationwide. A regional market, if it be large enough and well enough defined, could be converted without involving the rest of the nation.

Because most commercially available methanol is made from natural gas, the extraction step in the process has been covered in the 5-Year Program EIS and section IV.C of this paper. Production of methanol from natural gas, depending on the precise technology used, may lead to additional discharges of atmospheric pollutants with resultant impacts on local air quality, acid rain, stratospheric and tropospheric ozone, and greenhouse gasses. The production process may also lead to discharges of contaminated and heated water into streams, rivers, and lakes.

VI.A.1.c Ethanol

As is true with methanol, two different forms of ethanol are potential alternative fuels. E95 is 95 percent ethanol and 5 percent gasoline. Like M100, users are showing little interest in E95. E85 consists of 85 percent ethanol and 15 percent gasoline. Through 1995 users have shown only modest interest in E85 vehicles. However, in May 1995, General Motors announced that Chevrolet S-10 and GMC Sonoma pickup trucks produced in the 1997 model year and thereafter will be flexible fueled vehicles that can use either gasoline or E85 (EIA 1996). Results of this availability remain to be seen.

The principal problem with ethanol is its high cost. Present interest undoubtedly stems from subsidies in the form of exemptions from Federal and some state excise taxes. The restructuring of farm subsidies in the recent Farm Bill may permit the elimination of ethanol subsidies without a major drain on the Federal Treasury created by additional requirements for crop price support payments.

Because ethanol is corrosive and an absorbent of water, it cannot be transported through conventional pipelines. These characteristics make it incompatible with present liquid fuel distribution systems. A viable, large-scale ethanol industry requires a new infrastructure including new transportation, storage, and dispensing equipment.

Distillers produce ethanol through the fermentation of a sugar-containing biological product. Corn is the feedstock most widely used for ethanol production in North America. Energy experts expect corn to serve as the feedstock of choice for additional future ethanol production (Montgomery and Sweeney 1991).

Farmers may grow additional corn needed to meet expanded ethanol demand principally on land now considered marginal for crop production. They will have to remove land from less intense uses to devote to this intensively cultivated row crop. This action will result in significant increases in soil erosion, fertilizer runoff, and systemic effects through expanded uses of pesticides and herbicides in the case of no-till cultivation. The net effect will be deteriorated water quality through siltation, eutrophication, and chemical toxicity. Upland wildlife habitat will be diminished through loss of cover and the effects of chemical toxicity.

Wildlife will also be adversely affected by the additional rural activity associated with the more intense agriculture.

Production of ethanol uses great quantities of water and leads to releases of large quantities of oxygen depleting materials into streams and rivers. The net effect is significant further deterioration of water quality. Ethanol production also has deleterious impacts on local air quality through releases of hydrocarbons and on greenhouse gases through release of large quantities of CO_2.

VI.A.1.d Electricity

The future of electric vehicles is dominated by state mandates for zero emission vehicles (ZEV's). Starting in 1998, California, New York, and Massachusetts require that 2 percent of the vehicles sold in the state be ZEV's. The requirement increases incrementally to 10 percent in 2003 (EIA 1996). Electric vehicles are the only ones that have zero emissions (at the point of use).

Electric vehicles suffer from some performance problems; however, the ultimate limitations on electric vehicle acceptance revolve around technical problems with batteries. Batteries are too heavy, take too long to recharge, do not hold sufficient charge, and (most important) are much too expensive. Until these problems are solved, or at least ameliorated, consumers are unlikely to freely choose electric vehicles over vehicles powered with internal combustion engines. The only way to overcome this rejection would be to bribe consumers to take electric vehicles or to do as the three States are and force the automobile companies to bribe consumers.

A recent study concluded that if standard lead-acid storage batteries power a large fleet of electric vehicles, substantial lead would be deposited in the environment as a consequence of the manufacturing process. According to this study, the social cost of the additional lead would be greater than the costs associated with the pollutants that would be displaced by the electric vehicles.

If the battery technology problems are overcome, or if ZEV mandates are effective, the substantial adoption of electric vehicles will greatly increase the demand for electricity. Meeting increased demand for electricity will lead to the kinds of environmental impacts noted in section VII.A which deals with electricity generation.

VI.A.1.e Hydrogen

Hydrogen powered fuel cells could be used in a new generation of vehicles designed to minimize final use air pollution in urban areas. However, this technology faces three major impediments:

- the fuel is dangerously explosive
- no distribution network exists
- hydrogen production is expensive -- requiring large amounts of electricity.

If the U.S. Government decided to pursue hydrogen fuel cell vehicles on a large scale, we would have to develop major additions to the electricity production infrastructure. The impacts of this development are discussed in the section VII.A on electricity generation.

New research on the use of enzymes found in organisms growing in extreme conditions has found a way to produce hydrogen from glucose and presumably other sugars and similar materials including perhaps even cellulose. If this approach proves to be financially feasible, it may become a major source of energy for the future. It will be decades before this technology is implemented on a broad scale.

VI.A.2 More Efficient Vehicles

One good way to conserve energy, or in this case to substitute for OCS oil, is to adopt more efficient transportation vehicles. There are three promising ways to do this, improve the efficiency of engines and transmissions, lighten and streamline vehicle bodies, and switch more cars to diesel. Government interference in the market place often leads to unintended consequences. Potentially, that could be the case with more fuel-efficient vehicles and other government energy programs. For instance, more fuel efficient cars might encourage car owners to drive more partially negating fuel savings. In addition, greater automobile efficiency might discourage use of even more efficient alternative modes of transportation.

VI.A.2.a Improved Engines and Transmissions

Automobile manufacturers have responded to the CAFE standards by steadily increasing the fuel economy of cars sold in the United States market. Major contributors to this increased efficiency have been more efficient engines and transmissions. Although more efficient engines and transmissions presumably burn gasoline for fuel, the potential exists for this alternative to decrease further the amount of oil consumed in automobile transportation. The problem with this alternative is that it increases the cost of new automobiles. No negative environmental consequences stem from this alternative. This desirable outcome is undoubtedly the basis for the current Government-private industry partnership to produce a more fuel efficient automobile.

VI.A.2.b Lighter, More Streamlined Vehicle Bodies

Vehicles, especially automobiles, with lighter, more streamlined bodies would also save additional fuel. Auto manufacturers have made significant progress in this direction, but more is still possible. Increasing the proportions of aluminum and plastic could reduce vehicle weights. Lighter weight vehicles have several problems:

- they are more expensive
- they tend to be less safe
- they may be more expensive to repair in case of collision damage
- they may be less acceptable to buyers looking for a “solid” steel car.

More streamlined cars may be less acceptable because buyers find the style of such cars too extreme for their taste. More streamlined bodies should have few negative environmental consequences. Environmental consequences of lighter bodies would depend on the materials of which they are made. Plastic usually uses oil as a raw material so the amount of oil used in the construction of lighter vehicles based on plastic is likely to increase. However, the life cycle oil use of the lighter vehicles is likely to decrease. Similarly, aluminum requires more energy to produce than the amount of steel needed to perform the same function; nevertheless, life cycle oil savings are likely to accrue to an increase in the proportion of aluminum.

VI.A.2.c More Diesel Cars

Diesel engines tend to be more efficient than gasoline engines for any particular application. Diesel engines dominate markets for trucks, buses, and trains. Consumers resist diesel engines in cars because:

- their performance characteristics are poorer than gasoline engines
- they are more expensive
- they are harder to start
- they are smelly and smokey
- diesel fuel is less widely available than gasoline.

However, if consumers could be convinced to accept them, diesels could effect a major decline in oil use.

VI.A.3 More Efficient Transportation Systems

The United States has the least energy efficient transportation system among the major industrialized countries. Improving the efficiency of this system would reduce the single largest form of oil use in our economy. Among the possible approaches for achieving this end are:

- using more mass transit and car pools
- increasing the percentage of rail transport
- designing and building more efficient road systems.

VI.A.3.a More Mass Transit and Car Pools

A large portion of automobile use is for commuting to and from work. A large percentage of workers commute alone in their automobiles. Enticing commuters to use mass transit and car pools on a large scale would save vast quantities of oil. Although such a switch in transportation mode should save money for commuters, a majority are unwilling to make the switch because they like the freedom and convenience afforded by driving one's own car. The environmental consequences of switching to mass transit and car pools would be entirely positive. Air, water, land, noise, and visual aesthetics would all be improved.

VI.A.3.b Greater Use of Rail Transportation

Trains are more energy efficient than trucks, buses, cars, or planes. Increasing the portion of goods and passengers traveling by rail would save oil. Train travel is avoided because it tends to be slower, door-to-door, than the other modes listed and it often entails mode changes to reach destinations not served by railroad lines. Increased rail travel would tend to have positive environmental consequences although there could be negative impacts from construction if rail transportation became sufficiently popular to require additional rail lines. However, net impacts to air, water, land, and noise would all decline.

VI.A.3.c Improved Road Systems

Road systems can be designed to handle the same volume of traffic more efficiently. Adequate road space to handle peak loads at normal speeds is one way to do this. Timing traffic lights and installing more "smart" traffic lights to keep high volume traffic moving are others. Building more free flowing highways is a third way to increase efficiency. Unfortunately, these alternatives tend to be expensive and to lead to higher use by motorists abandoning mass transit for the freedom and speed of individual commuting. The environmental consequences of more efficient roads depends on the impacts of construction and the space usurped by increased road space.

VI.A.4 Less Motorized Transportation

Another way to save oil currently going into motorized transportation is to do less of it. People would tend to use less transportation if its price increased. Taxes could be used to decrease transportation use. Given the unpopularity of increasing taxes, it is unlikely that this alternative will be used to any great extent. Other approaches to less motorized transportation include telecommuting and non-motorized vehicles.

VI.A.4.a Telecommuting

Allowing workers to use computers and to perform other work related activities in their homes saves the oil that would be used in commuting. Telecommuting is limited by:

- work unsuited to the home environment
- supervisors who fear loss of control

- the difficulty in avoiding interruptions from other family members.

Environmental consequences of telecommuting are all positive.

VI.A.4.b Non-motorized Transportation

Another way to cut back on the use of motorized transportation is the use of non-motorized forms of transportation. In practical terms this means bicycles and walking. Both modes tend to be more time consuming and limited in flexibility compared to automobiles. However, with more jobs being located in suburban campuses near workers' homes, non-motorized transportation has become more practical for more people. Using bicycles and walking have only the most minimal negative environmental consequences.

VI.B Industrial Sector Uses

The major alternative to oil in the industrial sector is natural gas. Environmental consequences of expanded natural gas production are covered in section IV.C and the 5-Year Program EIS. The other alternatives to oil in the industrial sector tend to be identical to those for natural gas. These other alternatives are discussed in section VI.B because natural gas is a more important fuel in the industrial sector than oil.

VI.C Residential and Commercial Sector Uses

The major alternative to oil in the residential and commercial sectors is natural gas. Environmental consequences of expanded natural gas production are covered in section IV.C and the 5-Year Program EIS. The other alternatives to oil for the residential and commercial sectors tend to be identical to those for natural gas. These other alternatives are discussed in section VII.C because natural gas is a more important fuel in the residential and commercial sectors than oil.

VI.D Electricity Generation

One of the major alternatives to oil for electricity generation is natural gas. Environmental consequences of expanded natural gas production are covered in section IV.C and the 5-Year Program EIS. The other alternatives to oil for electricity generation tend to be identical to those for natural gas. These other alternatives are discussed in section VII.A because natural gas is a more important fuel for electricity generation than oil.

VI.E Non-energy Uses

The major non-energy uses of oil and NGL's are as a feedstock for chemicals and as a raw material for solvents, lubricants, asphalts, and waxes. The alternatives for both types of non-energy use tend to be identical so they are discussed together.

VI.E.1 Alternative Raw Materials

Oil and NGL's consist of hydrocarbons of varying complexity. Substitutes must be hydrocarbons with roughly similar chemical compositions. Thus, the list of substitute raw materials is limited to coal and biological sources.

VI.E.1.a Coal

For the most part, coal is suitable only for the chemical feedstock uses of oil. Although coal is a cheap and abundant raw material, it tends to require more (and more expensive) conversion before it is suitable as a substitute for oil and NGL's. In a nutshell, coal can be converted into most chemicals presently processed from oil and NGL's; however, it is usually much more expensive to do so. The environmental consequences of increased coal extraction are discussed in section VII.A.1.a, where coal is considered as an alternative fuel for generating electricity.

VI.E.1.b Biological Products

Products from living biological entities can be used for most non-energy uses of oil and NGL's. The important thing to understand is that very large quantities of oil and NGL's are used to produce non-energy products. To harvest enough of a biological product to make an important contribution to this industry would require a large scale production system. Presently, some biological products do compete as feedstocks and for such products as waxes. Soy beans are the most obvious domestic example. The vast acreage committed to soy bean production is an example of the kind of commitment that would have to be mounted to substitute for a meaningful percentage of oil and NGL's. The major impediment to such conversion is its cost.

Greatly increasing the harvest of biological resources would mean conversion of significant land area to this new use. The result would depend on the biological source and the region chosen to provide that source. Regardless of the option chosen, consequences would almost undoubtedly include:

- loss of wildland habitat for many species, including those that are threatened and endangered
- increased soil erosion
- water quality degradation
- added dust and related forms of air pollution
- increased use of insecticides, herbicides, and other potentially harmful agricultural chemicals.

VI.E.2 Using Less of the Products

Among the major forms of conservation is using less of the oil-based products. In the case of chemicals, lubricants, etc., this would entail lowering our standard of living. It would mean things like painting our houses less frequently, cutting back on consumption of pharmaceuticals, and not cleaning clothes and houses so frequently. A major future use of plastics made from oil and NGL's is as lighter-weight major parts for automobiles. Cutting back on plastic parts for automobiles would make the autos heavier which would expand their need for oil products as fuel. All-in-all our society wastes relatively little of its production of oil-based chemicals. Reduction of this use would lead to a lower standard of living with questionable positive impacts on the natural and human environments.

VI.E.3 Recycling

Plastics are commonly recycled. Recycling solvents, lubricants, and other oil-based chemicals would also seem to be an ideal way to save some of the raw material input. Unfortunately, used chemicals of these types are often contaminated with dangerous and environmentally damaging materials. Removing these contaminants is often more expensive than the cost of virgin raw materials. For example, recycled motor oil from automobiles has mostly been mixed in with residual oil and burned in boilers.

Disposing of the contaminants can lead to processes that add to air and water pollution. Where processes can be developed to reprocess these types of chemicals in an environmentally acceptable manner, the result could be a saving of oil and NGL's with relatively benign environmental consequences.

VII Alternatives to Natural Gas and Their Environmental Impacts

The same five basic ways exist to replace either OCS gas or oil: import, produce onshore, switch fuel, substitute fuel-saving technology, or accept less service. The principal alternatives to OCS natural gas are oil and gas from onshore production. Oil importation and onshore gas production Are covered in section IV.C. This section will review the other potential substitutes for OCS gas.

VII.A Electricity Generation

Electricity generation is the fastest growing use of natural gas. However, alternatives to using OCS natural gas for electricity generation have a high potential to decrease the future use of this fuel. As discussed in section III.C, natural gas is especially well suited to producing ramping power to meet peak loads. This is the most expensive and valuable type of power production. However, combined-cycle gas plants are finding more and more application to base-load and intermediate power supply.

VII.A.1 Alternative Fuels

Table 8 provides statistics on utilities' capability to generate electricity using different fuels and the amount of electricity they generated using the various fuels in 1994. Table 9 shows planned additions to generating capacity from 1996 to 2004.

VII.A.1.a Coal

As table 8 makes clear, in the United States more electricity is generated using coal than any other fuel. Coal is best suited to base-load and slowly-ramping power production because coal-fired power plants are relatively slow to bring on and off line. For the proper application, coal-fired power plants compete reasonably well with other generators. However, in order to be efficient, coal plants must be large. In addition, air pollution control regulations require the installation of expensive pollution control equipment. As a result, building a new coal plant entails a very significant capital investment with interest costs that can become prohibitive if the cost of money rises. The few new coal plants table 9 shows in the planning stage testify to utilities attitude toward risks associated with high interest rates and air pollution regulations.

Coal extraction is almost synonymous with negative environmental impacts. It causes especially severe impacts on water resources which are degraded by acidic drainage from active and

Table 8. U.S. Electric Utilities 1994 Generating Capability and Net Generation.

Fuel	Generating Capability (megawatts)	Net Generation (million kilowatt-hours)
Coal	301,098	1,635,493
Petroleum	69,919	91,039
Gas	133,854	291,115
Nuclear	99,148	640,440
Hydroelectric Pumped Storage	21,168	-3,378
Renewable		
Hydroelectric (conventional)	75,196	247,071
Geothermal	1,747	6,941
Biomass*	515	1,988
Wind	8	0
Solar Thermal	0	0
Photovoltaic	4	3
Total	702,658	2,910,712

Source: U.S. Department of Energy, Energy Information Administration. *Electric Power Annual 1994, Volume I.* DOE/EIA-0348(94/1), July 1995.
*Biomass includes wood, wood waste, peat, wood liquors, railroad ties, pitch, wood sludge, municipal solid waste, agricultural waste, straw, tires, landfill gases, fish oils, and other waste.

abandoned mines and by silt from earth movement which is especially serious in strip and auger mining. Ground water is often polluted or disrupted by coal extraction because coal seams serve as the aquifer in many locations. Coal mining also is associated with air pollution from dust and machinery exhaust. The machinery also produces noise pollution. Coal's impact on visual aesthetics is especially severe because the surface scars from strip mining and the mountainside cuts from auger mining have an especially significant effect on scenic mountain areas.

VII.A.1.b Nuclear

Table 9. Planned Capability Additions at U.S. Electric Utilities, 1996-2004.

Energy Source	Number of Generators	Capability (megawatts)
Petroleum & Gas	302	30,525
Coal	13	4,530
Nuclear	0	0
Hydroelectric	68	531
Renewable	5	314
Total	388	35,899

Source: U.S. Department of Energy, Energy Information Administration. *Electric Power Annual 1994, Volume I.* DOE/EIA-0348(94/1), July 1995.

Nuclear power plants are almost exclusively used for base-load power production. Although nuclear power was originally sold as a very cheap form of electricity generation, it has proven to be quite expensive. Providing the margin of safety society expects from a nuclear plant requires safety systems that multiply by several times the cost of building a nuclear plant. Similarly, safe operations cost many times the operating costs originally envisioned. Finally, finding a socially acceptable location for disposing of the spent nuclear fuel cells is much more expensive than originally expected.

From table 8 one can see that nuclear plants have the highest ratio of generation to capacity of any major category of electric generation. Where they are installed, they are usually the base-load work horses of the utilities' generation systems. Nonetheless, the lack of any planned nuclear capacity addition demonstrates their prohibitively high costs (see table 9). In the next 15 or 20 years many presently operating nuclear units are scheduled for decommissioning. If this occurs on schedule, it will lead to a significant increase in the demand for other forms of electricity generating capacity.

Compared with other forms of large-scale electricity generation, nuclear power has relatively minor environmental impacts. Mine tailings from uranium mining have caused radioactive water pollution in the West, but this is more a result of formerly inadequate regulation or lax enforcement than it is a problem with present production. The tremendous cooling needs of nuclear reactors can lead to abnormal temperature increases in bodies of water used for plant cooling. The size of the containment vessels can also cause visual aesthetic degradation.

VII.A.1.c Hydroelectric

Many of the best hydroelectric sites in the U.S. have already been utilized or set aside for aesthetic reasons. Table 9 shows that hydroelectric power won't make a significant contribution to additional domestic electricity generation. Pump storage, which is a method for storing less expensive base-load power from off-peak hours for meeting peak demand could substitute for some natural gas-fired turbines used for peaking power. Environmental impacts from pump storage facilities tend to be localized and to consist of destruction of wildlife habitat and, in open systems, disruption of stream flows.

VII.A.1.d Geothermal

Geothermal electricity generation is limited by the availability of geothermal resources and the inadequate technology to take advantage of many forms of geothermal energy. Geothermal generating stations create air pollution, water pollution, noise, and negative aesthetic consequences.

VII.A.1.e Biomass

Next to geothermal, table 8 shows biomass making a larger contribution to U.S. electricity generation than any other non-conventional power source. Most of the biomass burned for power is wood or specific types of waste wood products. Obviously, this power source is dependent on a large supply of low-cost wood.

At some point trees must be cut to obtain the wood for generating power with this form of biomass. Cutting trees can lead to additional water pollution from soil erosion caused by timber road construction and skidding the fallen trees. Ground without the protection of trees, especially if it is burned, may also be subject to increased erosion. The logging also creates a location unsuitable for wildlife requiring trees for food, cover, and protection. Some of the displaced wildlife could be endangered species.

Another source of biomass for power is municipal solid waste. Burning solid waste without creating air and water pollution problems is costly. This means such systems usually cannot compete with other sources of power without sizable subsidies. However, in locations where suitable sites for land fills are becoming inaccessible, subsidies may be appropriate. Some individual solid waste incinerators, for example the Lancaster County (Pennsylvania) Resource Recovery System, can solve the solid waste disposal problem; generate electricity; and produce negligible air, water, and land pollution. Unfortunately, the combination of cost and technical sophistication makes waste to power systems unlikely sources of significant electricity generation in the near future.

VII.A.1.f Wind

The amount of electricity generated by wind power has expanded greatly over the last decade driven in part by significant technological improvements. In addition, vastly expanded wind-powered electric generation facilities have been proposed for several locations in the West. This expansion in wind generating facilities has been fueled by generous subsidies for building and operating these generators. Without the subsidies wind power would be viable only in the very best locations facing the highest alternative generating costs. Nevertheless, the contribution of wind power to U.S. electricity generation is minimal, as shown in table 8; furthermore, it is unlikely to augment its contribution to any great extent in the near future according to table 9.

Wind power has not turned out to be the environmental panacea that some expected. In order to produce a measurable amount of electricity, wind powered generators must be located in groups called farms. Wind farms occupy large tracts of ground and modify the natural land environment. Because most wind farms are located in arid, mountainous country, construction of the pads and access roads leads to disturbance to large areas of sensitive land. The result is greatly increased soil erosion compared with what it would be from more traditional land uses. The increased erosion can lead to siltation in nearby streams depending on the location of the wind farm.

Wind farms also lead to high raptor mortality. Scientists are not sure why this is occurring; however, the frequency and severity of this mortality is great enough to raise concerns. Of very serious significance is the impact of wind farms on visual aesthetics. Optimal placement of wind powered generating facilities is on the crests of ridges or along the sides of canyons. These locations are often the highlights of scenic areas. The large numbers of generators in stark relief against the sky creates a devastating loss of aesthetic value to some observers. Another problem with wind farms is their interference with the transmission of electromagnetic signals. Although wind farms are usually located in lightly populated areas, neighbors and nearby travelers experience interference with radio, television, and other communications media transmission. Wind farms are also a source of noise pollution.

VII.A.1.g Solar

Energy from the sun can generate electricity in several different ways:

1. A parabolic mirror can focus a patch of the sun's energy on a single point. The heat from many mirrors can be transferred to a generating station which uses the heat to create steam to power a steam turbine.
2. Alternatively a field of mirrors can be focussed on a single central point where the heat powers a steam turbine.
3. Photovoltaic cells can be used to convert the sun's energy to electricity through a chemical process.

All solar generating technologies are very expensive. However, photovoltaic cells are finding increased use to power facilities far from existing power lines. In recent years the cost of photovoltaic cells has declined while their reliability has improved. Now, in many cases it is cheaper to install photovoltaic cells than run a long-distance power line. The recent development of a successful photovoltaic film should significantly expand the range of applications for photovoltaic power. Nevertheless, solar powered electricity will remain a high cost alternative for the foreseeable future and will not make a major contribution to electricity generation because of its cost. Tables 8 and 9 document this reality.

Solar powered electricity generation on a small scale has relatively minor environmental impacts. However, if solar power is ever to make a measurable contribution to national electricity generation, vast areas of land would have to be given over to this technology. Although the areas best suited to solar energy tend to be arid and thus fragile, many areas might be flat or on gentle slopes and not as susceptible to wholesale erosion as wind farms. Nevertheless, large scale loss of vegetation and wildlife habitat, soil erosion, and resulting water pollution can be expected from large scale solar generating facilities. Such facilities could also be aesthetically displeasing.

VII.A.1.h Other Sources

Other potential sources of electric power such as ocean thermal, tidal, and ocean currents lack the potential to make a serious contribution to U.S. electricity supply. These alternatives are too expensive, lack feasible technology, or both. It is extremely unlikely that any exotic form of electricity generation will make even a one percent contribution to the U.S. electricity supply during the planning period for this program.

VII.A.2 More Efficient Electricity Generation

A meaningful amount of the natural gas and oil used to generate electricity could be saved by using more efficient generating equipment to produce the same amount of electricity as now. Examples of how this could be done included:

- replacing aged equipment with modern conventional equipment
- replacing straight turbines with much more fuel efficient combined cycle systems
- adopting the next generation of nuclear reactor once and if they become available
- building one of the new generation of coal-fired generating plants such as atmospheric fluidized bed, pressurized fluidized bed, or limestone injection

The problem is that modern, efficient generating plants are very expensive. Power companies may have trouble justifying the expenditures to their stock holders on a financial basis. Furthermore, state regulatory agencies may be unwilling to allow additions to rates for plant construction while they allow standard rate adjustments for fuel costs. Saving natural gas and oil through more efficient generation would reduce the incidence and risk of all the environmental impacts associated with the natural gas and oil production saved. Some of the conserved resources would have come from the OCS.

VII.A.3 More Efficient and Less Electricity Consumption

Both more efficient use and less use of electricity by the industrial, commercial, and residential sectors could save the fuels used to generate that electricity. These types of savings will be discussed in sections VII.B and VII.C.

VII.B Industrial Sector Uses

VII.B.1 Alternative Fuels

The trend in the industrial sector is to switch to natural gas or electricity. This means that other fuels are less suitable for industrial applications, more expensive, or both. Oil is the most likely alternative fuel that most industries would choose as a substitute for natural gas. Impacts from oil production are covered in section IV.C and the 5-Year Program EIS.

VII.B.1.a Coal

Coal can be an effective alternative to natural gas in industrial applications where rapid peaking is not a requirement. However, it is an expensive alternative in all but the largest applications. Among the characteristics that add to the cost of coal use are:

- the expense of efficient-sized coal-burning facilities
- the need for expensive air pollution control equipment
- the expense of transporting and handling coal.

The environmental impacts associated with coal are covered in section VII.A.1.a.

VII.B.1.b Electricity

Electricity can be substituted for natural gas (and oil) in many industrial applications. Although electricity tends to be more expensive than the use of a raw fuel, it moves the source of air pollution to another location which may have less stringent pollution control regulations than the industrial site. Furthermore, an electric utility can achieve economies of scale in pollution control that might not be available to the individual firm. The environmental impacts attributable to the generation of electricity are dependent on the fuel used and these are covered in section VII.A.1.

VII.B.2 More Efficient Energy Use

Although the industrial sector as a whole spends a considerable amount of time and money developing methods for using energy more efficiently, there remain opportunities for saving vast quantities of energy in the industrial sector. Many consulting firms make it their business to help firms use energy more efficiently, but they tend to help only those firms with high enough levels of inefficiency to pay a portion of efficiency savings to a consultant. Many smaller opportunities for improvements go unaddressed. This is true for the use of natural gas, oil, electricity, and even other energy inputs such as coal.

One way firms in the industrial sector can improve their energy efficiency is by adopting state-of-the-art equipment. In many cases a new process or space heating and cooling equipment can save enough in energy costs to pay for itself in a reasonably short pay back period. Related savings can be reaped by choosing equipment that is the right size in terms of energy efficiency for the task at hand.

Another way firms can save energy is through improving the energy efficiency of their industrial processes. Although most "reengineering" activities in industry are aimed at using labor more efficiently, the same approach can be used to save on the use of energy. Combinations of new processes with new, properly-sized equipment can lead to especially significant energy savings.

Although some negative environmental impacts may be associated with the production of materials or equipment installed in the process of achieving greater energy efficiency, these impacts tend to be negligible. Thus, improvements in the efficiency with which the industrial sector uses energy are almost entirely beneficial to the environment.

VII.C Residential and Commercial Sector Uses

VII.C.1 Alternative Fuels

Just as in the industrial sector, the trend in the residential and commercial sectors is to switch to natural gas, when it is available, or electricity. Residential and commercial facilities have relatively many alternative fuel options.

VII.C.1.a Electricity

When gas is unavailable, electricity is the fuel of choice for new residential and commercial facilities in all but the coldest parts of the country. Heat pumps are the technological breakthrough that has allowed electricity to compete with products made from oil. Environmental impacts from the production of electricity are covered in section VII.A.

VIi.C.1.b Oil

Among the products made from oil and available to the residential and commercial sectors are fuel oil, kerosene, and Liquified Petroleum Gas (LPG). Each of these products can be competitive with natural gas under certain circumstances, the most common of which is lack of access to a natural gas pipeline. Oil-based products are also well suited to areas where it is too cold for electric heat pumps to operate effectively. Impacts from oil production are covered in section IV.C of this paper and in the 5-Year Program EIS.

VII.C.1.c Coal

Coal is still burned in many older houses. Although coal is cheap, it is dirty and inconvenient to handle. Even in modern houses, coal is still used as an auxiliary source of heat, sometimes switching off with wood depending on relative costs or availability. The environmental impacts associated with coal mining are enumerated in section VII.A.1.a

VII.C.1.d Biomass (Wood)

Wood is burned for heat in many houses. The major problems with wood are the difficulty associated with handling and storing a sufficient quantity to maintain comfort over a long winter and the cost of cleaning the chimney to prevent fires caused by buildup of creosote. Cutting firewood in moderation may cause little negative environmental impact and may even serve to open up forests to let the remaining trees develop and to provide some ecological diversity. Where such cutting is carried to an extreme it may destroy forest habitat and lead to soil erosion resulting in long-term damage to the land and destruction of water quality. In addition, habitat for tree dependent wildlife may be lost with resultant loss of the wildlife population which may include endangered species.

Other forms of biomass can be burned or they can be processed into methane gas for use in a similar manner to natural gas. Municipal solid waste is an example. No use of biomass other than wood and solid waste burning makes even a negligible contribution to the supply of energy in the United States.

VII.C.1.e Solar

Solar energy is almost exclusively an auxiliary source of heat to the residential and commercial sectors. However, especially in sunny areas, the contribution of solar energy can be significant. More active forms of solar heating involving circulating hot water and fans to conduct hot air from warm to cool locations seem to be less satisfactory than more passive systems. Simple approaches to letting the sun warm parts of a dwelling, especially those made of heat retaining materials, work especially well. Solar energy also works effectively as an auxiliary water heating system. The problem is that these auxiliary systems need a main or a backup system including an alternative source of energy. Where the alternative source is electricity, the demand during times of low solar radiation could force electric utilities to provide relatively expensive peak demand at a cost to all customers whether or not they used solar heat.

Manufacturing solar energy capturing material could lead to environmental deterioration;

however, that environmental cost is likely to be minor. Environmental impacts of residential and commercial solar energy use at the point of capture are likely to be negligible.

VII.C.2 More Efficient Energy Use

As is true of the industrial sector, the residential and commercial sectors can use correctly-sized, state-of-the-art equipment to increase the efficiency of their energy use. However, in terms of more efficient use, these sectors have some specific steps open to them that have broad application across the sectors. Potentially most important is the use of better designs and materials. Better designs can take advantage of passive solar energy, minimize openings to the outside, and take into account air flow as well as temperature to maximize comfort. Better materials include multi-paned glass, insulated sheathing, and more effective insulation materials.

Insulation and weatherization can be especially effective in the residential sector. Programs to subsidize insulation and weatherization sponsored by electric utilities have cost-effectively spared the utilities from having to install expensive new generating plants. In more sophisticated applications, zoning and time-of-day controls can be used to hold down unnecessary energy use in large residences and commercial establishments. More efficient appliances and appliance use can also add to the efficiency of the residential sector.

Any negative environmental impacts from increased production of more energy efficient heating and cooling equipment and appliances would be only marginal. Therefore, almost all the improvements in energy efficiency in the residential and commercial sectors would have positive impacts on the natural environment.

VII.C.3 Less Energy Use

In the industrial sector, any decrease in energy use that was not associated with increased energy efficiency would lead directly to a decrease in production. In the residential sector less energy use might lead to lower utility; however, the trade off might be a reasonable one. For instance, less heating and cooling might lead people to change their dress habits without causing much inconvenience. Every day decisions like this could lead to positive impacts on the natural environment.

VIII A Note on "Conservation"

The two types of energy conservation, substituting energy-saving technology and using less of the energy service, share two important characteristics:

1. There may be some negative environmental impacts associated with any new equipment required to achieve the efficiency, but these impacts will tend to be marginal.

2. The net effect of these measures will generally be positive from an environmental point of view.

Furthermore, there is ample opportunity in our society to provide cost-effective subsidies to entice people to implement various conservation measures. Unfortunately the opportunities are not unlimited. Enticement to conserve will have to be constant and each additional unit of conservation after an initial period of success will become incrementally more expensive. In other words, conservation has an upward sloping supply curve just as most other goods and services do. Thus, our society could decide to save energy and save money in the process, but only for a while. Eventually, saving more energy would become too expensive to continue. Conservation, then, can be an important part of a rational future energy plan, but it can only be one of several alternatives adopted to meet future energy demands.

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