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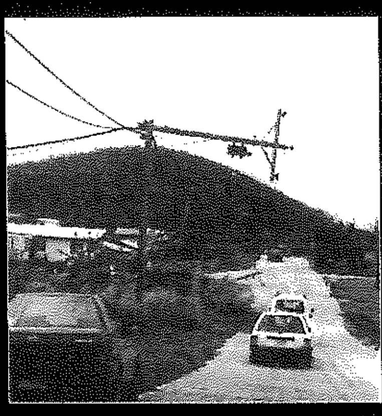
HAWAIIAN ISLANDS HAZARD MITIGATION REPORT



U.S. Department of Energy

Office of Emergency Management
for the State of Hawaii

Hawaii Hazard Mitigation Study

This Hazard Mitigation Study was conducted by the U. S. Department of Energy, Office of Emergency Management, under contract to the State of Hawaii. Complete funding for this study was provided by the State of Hawaii and the Federal Emergency Management Agency.

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Executive Summary

On September 11, 1992, Hurricane Iniki passed over the Island of Kauai causing over $2.4 billion in damage. As a result, President Bush declared Kauai a major disaster area. Such a Presidential Declaration activates various sections of the Robert T. Stafford Disaster Relief and Emergency Assistance Act which provides the framework for implementation of a variety of programs, including hazard mitigation.

Following Iniki there was an island-wide electrical blackout and telecommunications and commercial water services were almost entirely curtailed. Sewage treatment plants were forced to discontinue operations thus threatening pollution of surrounding waters. The loss of electricity closed gas stations and refrigerated food spoiled in homes, hotels, stores, and warehouses. Many businesses, homes, and hotels were damaged or destroyed. Surface transport was slowed or halted by debris, and rental cars were abandoned by tourists hastily departing Kauai. Credit cards could not be verified and cash was not available from automatic teller machines. Tourism, the mainstay of the Kauai economy, was disrupted and at the time of this study had still not returned to pre-Iniki levels.

To date the Federal Emergency Management Agency (FEMA) has incurred $232 million in disaster relief efforts. Under Section 404 of the Stafford Act, 10 percent of this amount (more than $23 million) became available to the State and counties of Hawaii and other not-for-profit corporations and entities.

The United States Department of Energy (DOE) and the State of Hawaii executed a Memorandum of Understanding (MOU). This MOU stipulated that DOE conduct an Energy Hazard Mitigation Study of the six main Hawaiian Islands (Hawaii, Kauai, Lanai, Maui, Molokai, and Oahu).

This hazard mitigation report, jointly funded by FEMA and the State of Hawaii, will assist FEMA in determining the allocation of these funds. It also addresses the various hazard mitigation measures which, if implemented, would reduce losses on Hawaii from future natural disasters (i.e., hurricanes, extreme winds, earthquakes, and volcanic activity). It focuses primarily on the Hawaiian energy industry including electric utilities, the petroleum industry, and the gas industry. Additionally, it highlights the maintenance of lifeline activities such as water pumping, sewage treatment, telecommunications services, and food distribution which are heavily dependent upon electricity. Moreover, it will identify and prioritize candidate proposals to improve the emergency preparedness of Hawaii's energy systems and reduce its vulnerability to future disasters.

HAZARD MITIGATION PROPOSALS

The specific proposals included in this report represent possible approaches to solve or mitigate problems caused by hurricanes, extreme winds, earthquakes, and volcanic activity. These proposals exemplify ideas derived from many sources including: the electrical, petroleum, gas fuel, and lifeline industries on Hawaii, Hawaii State and county agencies and officials, the U. S. Army Corps of Engineers, FEMA, and DOE study participants.

Each proposal addressed in this Hazard Mitigation Report was examined, discussed, and either recommended or not recommended. The recommendations in many cases were that the proposal be studied in greater detail to evaluate its overall feasibility or be further examined for implementation on a case by case basis.

The proposals in this report can be divided into three categories: public safety, long term hazard mitigation, and improvement of the reliability of the Hawaiian energy supplies. The criteria for evaluating proposals within each category differs, but it is normally recommended that proposals relating to public safety be funded first. Those proposals providing long term hazard mitigation and having a benefit/cost ratio greater than one funded second, and those which do not have favorable benefit/cost ratios, but improve the reliability of Hawaiian energy supplies, funded third. However, while the Hawaiian Islands are subject to hurricanes, earthquakes, volcanic activity, and extreme winds, the expected intervals between these potentially damaging natural hazards is 25 years or more (See TABLE I Page 18). These hazards are too infrequent on Hawaiian Islands for benefit/cost ratios to be cost effective.

The proposals briefly summarized below include some of the major hazard mitigation proposals recommended in this study for electric utilities, the petroleum industry, the gas industry, and Hawaii's Lifeline industries. All of the energy proposals in the lifeline section of the hazard mitigation report relate to public safety, and will be evaluated based upon considerations for improving public safety.

RECOMMENDED HAZARD MITIGATION PROPOSALS

Proposals for Hawaii's Electric Utilities

Increase Electric Utility Fuel Storage
To conserve fuel supplies, mainland electric utilities can purchase power from neighboring utilities. Island utilities do not have this option and must be more self-reliant. In addition, following a disaster, an island utility's ability to obtain and receive new supplies of fuel may be severely compromised. An increase in the amount of fuel approved for inclusion in Hawaii's electric utility rate bases on from 30 to 35 days is recommended.

Reduce Electric Utility Oil Dependency
Hawaii is highly dependent upon oil-fired generation. When additional generation is needed, to satisfy load growth or to replace generation being retired, new sources of generation and fuels should be selected to minimize life cycle costs and maximize electric system reliability.

Close Radial Transmission Loops
A radial transmission line, a line extending outward from a substation or switching station, is inherently less reliable than a looped or closed line returning to the station. It is recommended that certain radial lines be evaluated to determine which should be looped to increase system reliability.

Eliminate Electric Generating Unit Cooling Towers
Several electric generating plants on Hawaii use water cooling towers. Water recirculates through the cooling towers and the power plants reuse the water. This conserves water, but the water being conserved often consists primarily of seawater too brackish for most other uses. Cooling towers are vulnerable to hurricane winds and increase power generation costs. Simpler, less costly, more reliable once-through cooling systems are recommended.

Proposals for Hawaii's Petroleum Industry

Decentralize Cooling Towers at Refineries

Refiners on Oahu should consider replacing large, centralized wooden cooling towers with smaller, decentralized units to reduce the potential for hurricane-related wind damage and associated operational downtimes. At a minimum, refiners should develop a contingency plan for responding to the loss of the central cooling tower using once through cooling with subsurface aquifers or other viable alternatives.

Identify Emergency Generator Requirements

In the absence of commercial electric power a large number of emergency generators are needed to maintain a minimum level of operations for the petroleum system. A sufficient number of portable generators should be reserved for key locations to permit an uninterrupted flow of petroleum products for civilian/essential services. The petroleum industry, on each of the islands, should conduct a survey to determine the quantity, voltage/power levels, and phase requirements of emergency generators for critical locations necessary for the continued distribution of petroleum products.

Modify Tank Trucks and Loading Terminals

The petroleum industry should consider an interim measure to modify all tank trucks to both top and bottom loading capability to increase the reliability of fuel loading following an emergency or natural disaster. Eventually all bulk petroleum distribution terminals should be standardized by converting all to bottom loading racks (pipes which are used to fill tank trucks).

Storage Tank Protection

The petroleum industry should consider protecting the newer, larger storage tanks by filling empty or nearly empty tanks with water when sufficient crude oil/refined product is not available and tanks appear to be in the direct path of an approaching Class 5 hurricane. (Note: Older tank bottoms and walls may not have the capability of accommodating the additional weight of water).

Enhance Emergency Crude Oil Resupply Capability at Oahu Refineries

The refiners on Oahu should consider making adjacent offshore moorings compatible so that in the event of one mooring being rendered inoperable, tankers would have the capability to offload at the other location. Consideration should also be given to building an onshore crude oil pipeline interconnection between the adjacent refineries for added emergency resupply flexibility.

Proposals for Hawaii's Gas Industry

Install Automatic Gas Shutoff Valves on Mainline Gas Pipelines in Urban Areas Exposed to Earthquake Risk
Following the Kobe Earthquake, severed gas lines continued to burn for several days. After a Texas Eastern Pipeline rupture in New Jersey, it took nearly 2 1/2 hours (750 turns on each of three valves) to manually shutoff the gas flowing to the ruptured segment. Installation of automatic mainline shutoff valves may be advisable in various places on Hawaii and in the Lahaina and Honolulu areas due to the population density.

Provide Maps Showing Critical Gas Line Shutoff Valves to Fire Departments
Where underground liquified petroleum gas (LPG) or synthetic natural gas distribution systems exist (Oahu, Hawaii, and Maui), the gas distribution companies should provide the county and local Fire Departments with maps showing the locations of pipelines and shutoff valves.

Proposals for Hawaii's Lifeline Entities

For the purposes of this study, lifeline entities on Hawaii include: Police, Fire, Medical Services, Telecommunications, Suppliers of Potable Water, Suppliers of Food, and Waste Water Treatment Facilities.

Priority Power Restoration For Lifeline Entities
The continued operation of lifeline entities are critical to Hawaii. It is recommended that, consistent with the overall restoration of electrical service, electric utilities be permitted and required by the State of Hawaii to provide priority restoration of electric power to lifeline entities.

Provide DBEDT With Emergency Generator Information
To expedite delivery and installation of emergency generators during an emergency, lifeline entities ***without*** emergency generators on site should provide the Hawaii State Department of Business Economic Development & Tourism (DBEDT) Energy Division, with information concerning their power requirements. Lifeline entities ***with*** emergency generators on site adequate to continue operations should also provide DBEDT that information.

Measures to Increase the Emergency Generator Reliability
The startup and continued operation of emergency generators has been a nearly universal problem wherever and whenever a disaster has occurred. The U. S. Department of Energy, Office of Emergency Management's disaster experience indicates that approximately one-third of emergency generators will not start when needed and a

further third of those that do start will cease to operate within 4 hours. DBEDT should provide voluntary procedural guidelines (listed within a proposal in the body of this report) to lifeline entities with emergency generators to assure reliable emergency generator operation.

U.S. Army Corps of Engineers Hazard Mitigation Study

Under a separately funded hazard mitigation study, the U.S. Army Corps of Engineers (ACE) will address those hazard mitigation measures relating to the reduction of damage from water inundation caused by hurricanes and tsunamis.

Hawaiian Energy Systems Hazard Mitigation Study

Introduction

DISASTER DECLARATION
On September 12, 1992, President Bush declared the Island of Kauai, Hawaii to be a major disaster area as a result of damage from Hurricane Iniki (FEMA-961-DR-HI).

OVERVIEW OF AUTHORITY
When a state Governor proclaims a State of Emergency and the President issues a major disaster declaration, various sections of the Robert T. Stafford Disaster Relief and Emergency Assistance Act provide the framework for implementation of a variety of programs, including hazard mitigation.

This hazard mitigation study is jointly funded by the Federal Emergency Management Agency (FEMA) and the State of Hawaii. The U. S. Department of Energy (DOE) and the State of Hawaii executed a memorandum of understanding whereby DOE agreed to conduct an Energy System Hazard Mitigation Study of the six main Hawaiian Islands (Oahu, Kauai, Maui, Hawaii, Molokai, and Lanai) and provide the State of Hawaii with an Energy System Hazard Mitigation Report.

PURPOSE OF THIS REPORT
Hurricane Iniki caused $2.4 billion in damages on the Hawaiian Islands, principally on Kauai. Following Iniki, FEMA incurred $232 million in disaster relief efforts. Under the provisions of Section 404 of the Stafford Disaster Relief and Emergency Assistance Act (PL 93-288 as amended), 10 percent of this amount became available for Hazard Mitigation measures intended to reduce the cost of future relief efforts. These funds are available to the State and counties of Hawaii and other not-for-profit entities. The purpose of this study is to identify and prioritize candidate proposals to improve emergency preparedness and reduce vulnerabilities to future disasters.

This report addresses various hazard mitigation measures which, if implemented, would reduce losses on the Hawaiian Islands from future natural disasters, including: hurricanes, earthquakes, volcanic activity, and extreme winds. This hazard mitigation report focuses primarily on Hawaii's energy industry including electric utilities, the petroleum industry, and the gas industry. The maintenance of lifeline activities primarily dependent upon electricity such as water pumping, sewage treatment, telecommunications services, and food distribution are also highlighted.

These proposals represent possible approaches to solve or mitigate problems caused by hurricanes, earthquakes, volcanic activity, and extreme winds. Each hazard mitigation proposal is examined, discussed, and the measures are either recommended or not recommended.

Under a separately funded hazard mitigation study, the U.S. Army Corps of Engineers (ACE) will address those hazard mitigation measures relating to the reduction of damage from water inundation caused by hurricanes and tsunamis.

EVALUATING THE PROPOSALS

The proposals in this report can be divided into three categories: public safety; long term hazard mitigation; and improvement of the reliability of the Hawaiian energy supplies, including electric utilities, the petroleum industry, and the gas industry. The criteria for evaluating proposals within each category differs, but it is strongly recommended that proposals relating to public safety be funded first, those providing long term hazard mitigation and having a favorable benefit/cost ratio second, and those which do not have favorable benefit/cost ratios, but improve the reliability of Hawaiian energy supplies, third.

All of the energy proposals in the lifeline section of the hazard mitigation report relate to public safety and will be evaluated based upon considerations of improving public safety.

Recovery and restoration costs and expected recurrence intervals for potentially damaging natural hazards are used in this hazard mitigation study for determining the benefit of various hazard mitigation proposals. The expense of implementing various hazard mitigation proposals is the cost of the proposals. Hazard mitigation proposals with benefit/cost ratios greater than one are recommended to be implemented.

Frequency of Natural Hazards Affecting the Hawaiian Islands

The expected recurrence intervals for potentially damaging natural hazards such as hurricanes, extreme winds, earthquakes, and volcanic activity affecting Hawaii are shown in TABLE I (On Page 18). Recurrence intervals (years) are based on historical frequency data. The intervals represent the expected time period between natural hazards with the potential to cause significant damage to the energy infrastructure. These intervals are not extreme value return periods of a particular natural hazard event. A summary of the historical frequency data reviewed for the study is presented in Appendix A.

I. Hurricanes

Hawaii has been impacted by three hurricanes since 1957. The most recent was Hurricane Iniki in 1992, which hit Kauai directly and affected Oahu. In 1982 Hurricane Iwa passed northwest of Kauai and affected both Kauai and Oahu. In 1959 the eye of Hurricane Dot passed over Kauai. Over the past 43 years (since 1950) Kauai has been impacted by three hurricanes and Oahu one hurricane. Hurricanes have had little or no impact on Maui, Hawaii, Molokai, and Lanai. Hurricane data was obtained from the National Climatic Data Center, U.S. Department of Commerce.

II. Earthquakes

Estimated earthquake event frequencies were investigated for the purpose of determining a time period for the benefit/cost analysis of this study. This data covers the period from 1834 to August, 1994. The expected time periods for earthquakes (shown in TABLE I Page 18) vary from 25 to more than 100 years, a single earthquake event frequency estimate can not be applied to all the Hawaiian Islands. Based on earthquake events equal to or greater than Magnitude 6.5, the Island of Hawaii's estimated frequency is 25 years, Kauai's frequency is more than 100 years, and the remaining islands 50 years or more. An earthquake magnitude of 6.5 and higher was selected because this earthquake level has the potential to affect the energy and lifeline infrastructure. The earthquake data was obtained from the National Geophysical Data Center, Oceanic and Atmospheric Administration.

III. Volcanic Activity

The benefits of hazard mitigation measures are based upon avoiding or reducing the cost of recovery and rebuilding following a disaster. Volcanic events on the Hawaiian Islands with the potential of affecting energy facilities are rare, but potentially can cause enormous damage. Volcanic events occur too infrequently for calculation of benefit/cost ratios greater than one, the level at which hazard mitigation measures become justified on a financial basis. Therefore, decisions for hazard mitigation will only be based on public safety and the reliability of energy facility operations. DOE has recently completed a study (Volcanic Hazards and Energy Infrastructure, LA-UR 95-1087) of volcano hazards for the Hawaiian Islands. Volcanic events for the last million years were reviewed. The volcanoes and island on which they occur are as follows:

ISLAND	VOLCANOS
Hawaii	Kohala Hualalai Mauna Kea Mauna Loa Kilauea
Lanai	None
Kauai	None
Maui	Haleakala
Molokai	Kalaupapa
Oahu	Honolulu Vents

Based upon the DOE study, only on the Islands of Hawaii and Oahu does volcanic activity have the potential to significantly damage energy facilities. The main concern on the Island of Oahu is the Honolulu vents and their location in densely populated Honolulu. The energy infrastructure could be affected by surges and ash fallout from hydrovolcanic activity and by ash fallout and lava flows from strombolian activity. On the Island of Hawaii the primary concern would be to the electric power lines. Lava flows and ash fallout could disrupt power delivery to utility customers. Designing power line systems to resist the hazards of lava flow is not cost effective. The dispersed location of power plants and the loop configuration of the power line system on Hawaii and Oahu should help to minimize the loss of electricity. When new energy facilities are located on Hawaii, the U.S. Geological Survey's map (MF-2193, 1992) showing lava-flow hazard zones should be considered. Using this data and the DOE report, the expected time periods for recurrence of volcanic events have been estimated for the purposes of this study, and are shown in TABLE I.

IV. Extreme Winds

Failure of transmission lines as a result of localized high wind has been reported on the Islands of Hawaii, Maui, and Oahu. These winds are not necessarily associated with hurricane events. The mountainous terrain of the islands can significantly affect wind speed acting upon transmission lines. Failures can involve a single tower or a localized section of the line. The expected time periods for extreme wind events have been assigned for the purposes of this study and are shown in TABLE I. The selected time periods are based on terrain and location of lifelines and the consequence to the public as a result of damage to the lifeline.

V. Tsunamis

Under a separately funded hazard mitigation study, the U.S. Army Corps of Engineers (ACE) will address those hazard mitigation measures relating to water inundation caused by hurricanes and tsunamis.

The Hawaiian Islands have a long history of damaging tsunamis. The earliest recording of a severe tsunamis in Hawaii was in 1837 when a tsunamis generated from Chile reached an elevation of 20 feet at Hilo and killed 46 people in the Kau District on the Island of Hawaii. Undoubtedly a number of severe tsunamis reached the Hawaiian Islands prior to 1837; however, no detailed records were kept. Since 1837, 16 tsunamis have caused significant damage.

Tsunamis are principally generated by undersea earthquakes of magnitudes greater than 6.5. Coastal landslides and volcanic eruptions also have generated tsunamis. Most of the destructive tsunamis in Hawaii have been generated from along the coasts of South America, the Aleutian Islands, and the Kamchatkan Peninsula. Approximately 25 percent of all tsunamis recorded in Hawaii originated from along the coast of South America, while more than 50 percent originated from the Kuril-Kamchatkan-Aleutian region of the north and northwest Pacific. The most devastating tsunami to hit Hawaii was the Great Aleutian Tsunami of 1946, which killed 173 people. Waves 55 feet high were produced in Hilo, and property damage amounted to $26 million (1946 dollars).

Local seismic events have also caused large tsunamis within Hawaii, especially on the southeastern coast of the Island of Hawaii. The 1868 tsunamis produced the largest waves of record in Hawaii with 60 foot waves reported on the South Puna coast of the Island of Hawaii. The most recent damaging tsunamis occurred on November 29, 1975, when waves generated by a local earthquake with an epicenter located on the South Puna coast reached elevations as great as 26 feet along the southeastern coast.

VI. Time Periods for Natural Hazards Used For Benefit/ Cost Analyses

TABLE I shows the time periods selected to perform benefit/cost analyses. The table values represent selected time periods over which natural hazards (hurricanes, earthquakes, volcanic activity, and extreme winds) could potentially damage energy and lifeline facilities on the Islands of Hawaii, Kauai, Lanai, Maui, Molokai, and Oahu. The shorter the time period shown in the table, the greater the likelihood of that type of natural hazard affecting that island. Within this report the time periods in TABLE I will often be referred to as a, "recurrence interval".

The time periods shown are based in large part on historical data (number of events and the affects on energy and lifeline facilities). The time periods reflect the location and relative number of the energy and lifeline facilities relative to the potential natural hazard. Densely populated islands have energy and lifeline facilities across a large proportion of the island and hurricane, earthquake, volcanic activity, or extreme wind events have a high probability of damaging critical energy and lifeline facilities. Less populated islands have fewer energy and lifeline facilities. The presence of critical energy and lifeline facilities in coastal areas also increases the probability of damage due to hurricanes and tsunamis.

TABLE I.
Expected Time Periods for Potentially Damaging Natural Hazards***

Used For Benefit/Cost Analyses

YEARS

	HURRICANES	EARTHQUAKES	VOLCANOS*	EXTREME WINDS**
HAWAII	100	25	25	25
KAUAI	25	>100	>1000	25
LANAI	50	>50	>1000	100
MAUI	50	50	>100	25
MOLOKAI	50	>50	>500	100
OAHU	50	>50	>100	25

* The periods listed are for volcanic eruptions with significant lava flows. Volcanic eruptions of an explosive nature have recurrence intervals of more than 500 years on Hawaii and more than 1,000 years on the other Hawaiian Islands.

** Transmission Lines located near or on mountainous terrain are subject to damage from extreme wind events.

*** Tsunami intervals are provided by the U.S. Army Corps of Engineers in their study.

Description of the Hawaii Energy Infrastructure

I. Hawaii Electrical System

Each island electrical system operates independently, meeting its own power requirements. None of the island systems are interconnected. The Hawaiian Electric Company (HECO) operates the electrical system on Oahu. HECO is a utility holding company and operates subsidiary utilities on Hawaii, Maui, Molokai, and Lanai. The direct HECO subsidiaries are the Hawaii Electric Light Company (HELCO) and the Maui Electric Co. (MECO). The Molokai Electric Co. and Lanai Electric are subsidiaries of MECO and indirect subsidiaries of HECO. Kauai Electric is now a division of Citizens Utilities Co. Citizens Utilities is a utility holding company headquartered in Connecticut, with divisions in Arizona, Idaho, Vermont, and Hawaii.

The electrical reserve (the percentage amount by which generating capacity exceeds peak load) required to insure reasonable electrical reliability is higher for island utilities than for mainland utilities. Under emergency conditions mainland utilities are able to rely on their interconnections with neighboring utilities for power supply support; island utilities cannot.

Electric utilities are highly vulnerable to damage from hurricane force winds. Hurricane wind loadings, flying debris, falling trees, slack power line conductors slapping together, and water inundation cause widespread mechanical damage to electric transmission and distribution systems.

In the event of a hurricane it is normal for an electric utility to terminate generation. For example, in 1989 as Hurricane Hugo approached, generation on St. Thomas, Virgin Islands was shut down. This common utility practice is followed for two reasons. First to ensure public safety. During a hurricane there are likely to be many energized (live) conductors laying on the ground or blowing in the wind. The second reason is to minimize damage of an electrical nature to generating, substation, and station equipment. A hurricane causes widespread short circuits and open circuits due to flying debris, trees falling, poles, towers, and crossarms breaking, slack power line conductors slapping together, and other reasons. These short and open circuits can extensively damage transmission and distribution equipment and, under extreme conditions, damage electrical generation. Terminating generation will not prevent mechanical damage to utility equipment during a hurricane, but will lessen electrical damage.

Public Safety Issues Related to Electricity

While the economy of Hawaii is dependent upon continued import of petroleum supplies, the maintenance of public safety and lifeline activities on Hawaii is, as it is in all industrial countries, dependent upon a continued supply of electricity. When electric power is lost, for whatever reason, many or all of the following may occur:

- Petroleum refineries and pipelines may be forced to shut down.
- Some telecommunications fail immediately; some later, when backup generators and/or batteries fail.
- Lack of power for pumping interrupts water and fuel supplies and halts sewage treatment.
- Security systems may be inoperative.
- Law and order can break down and looting may occur.
- Traffic jams follow signal failures.
- Hospitals and nursing home operations are impaired and people on home life support systems are jeopardized.
- The banking system sputters to a stop - account balances & credit cards can not be verified, and cash is not available from automatic teller machines.
- Retail trade on a cash basis only.
- Lack of refrigeration causes food to spoil in storage warehouses, stores, hotels, and homes.

These are just some of the problems that arise when the electricity supply is disrupted. Clearly, one of the highest priorities when a natural disaster occurs is to restore electric service. Hardening of the energy supply infrastructure to be more resilient in the face of hurricanes, extreme winds, earthquakes, and volcanic activity is clearly beneficial to the maintenance of public safety and lifeline activities on Hawaii.

II. Hawaii Petroleum System

Hawaii, in common with almost all island communities, is heavily dependent upon petroleum as its primary source of energy. Hawaii has no indigenous source of petroleum, and imports both crude oil and refined petroleum products. This hazard mitigation study examines the petroleum infrastructure of the six main Hawaiian Islands: Hawaii, Kauai, Lanai, Maui, Molokai, and, Oahu.

The State of Hawaii, located some 2,500 miles southwest of the U.S. mainland, is almost totally dependent on imported fossil energy resources, primarily petroleum. Petroleum provides approximately 90 percent of Hawaii's total energy needs as compared to only 40 percent of the Nation's total energy needs. Much of Hawaii's higher demand levels for petroleum is due to higher demands for jet fuel and fuel oil for electric power generation.

Approximately 45 percent of the crude oil processed by Hawaii's refineries comes from Alaska's North Slope with the remainder from Indonesia, Malaysia, China, and Australia. These sources are thousands of miles away and in some cases require weeks of transit time to arrive in Hawaii.

This relative isolation and lack of nearby sources of supply make energy planning, emergency preparedness and system reliability very important to the State of Hawaii.

Refineries

Hawaii has two refineries, both located 22 miles west of Honolulu, in the Campbell Industrial Park at Barbers Point on the Island of Oahu. The Chevron USA refinery has a rated capacity of 55,000 barrels per day. Chevron is the largest supplier of gasoline. The BHP Hawaii refinery has a rated capacity of 95,000 barrels per day. BHP is the dominant supplier of jet fuel. The combined production of these two refineries generally meet Hawaii's petroleum requirements, with the principal exceptions of low-sulfur diesel fuel, commercial jet fuel, and lube oils.

Both refineries receive crude oil through mooring facilities located approximately two miles offshore at Barbers Point. Each mooring facility is capable of accommodating tankers of approximately 100,000 deadweight tons. If necessary, both refineries have the capability of loading clean products (gasoline, diesel fuel, and jet fuel) at these moorings.

Each refinery has substantial tank storage for crude oil, unfinished products and refined products awaiting shipment to wholesalers or end-users. The combined storage of both refineries is over 9 million barrels.

In addition, both refineries are equipped with cogeneration plants that allow them to be self sufficient in electricity and generate steam used in the refining process. The refineries also receive process steam from the power plants owned by Kalaeloa Partners and AES Barbers Point, two independent power producers (IPPs) on Oahu. These IPPs also sell electric power to the HECO electric system on Oahu.

Pipelines

The Chevron and BHP refineries are connected to military and civilian terminals at Pearl Harbor, Honolulu International Airport, and Honolulu Harbor by land-based pipelines. Chevron has two pipelines, an 8-inch black oil (residual fuel oil) line to the Honolulu Hawaiian Electric Company tank farm in Iwilei and an 8-inch clean product (gasoline, jet, and diesel fuels) line terminating at Pier 30, Honolulu Harbor. BHP has one pipeline, a 10-inch clean product line terminating at Pier 51-A, Honolulu Harbor.

Underground pipelines from the Barbers Point refineries also supply jet fuel to the Hawaiian Fuel Facility on Sand Island, which is located across from the Honolulu Harbor and Airport Satellite Terminals. Two pipelines (one dedicated to bonded jet fuel and one dedicated to domestic jet fuel) transport fuel from the Satellite Terminal to the Airport Hydrant Fueling System.

Most of these pipelines only have one pump station with two pump/ electric motor units using only one at a time with the other as a spare. Typical pump/motor units on these relatively small pipeline systems range in size from 75-500 horsepower.

Terminals

Hawaii has relatively large storage terminals for petroleum in order to take advantage of economical shipments via large tankers. The largest storage terminals are located in the Honolulu Harbor/Airport and Campbell Industrial Park areas on Oahu.

Of the nearly 15 million barrels of non-military, primary, bulk-storage statewide, approximately 14 million barrels of storage is located on Oahu. The remaining one million barrels of terminal storage represent smaller terminals located in the harbor areas and at electric utility sites on the Neighbor Islands. While the terminals on the Neighbor Islands are relatively small, they are a critical part of the petroleum supply chain.

The average total inventories of most products are in the range of 40 to 45 percent of gross storage capacity. This is about 30 to 50 days of supply at normal consumption rates for most products. Commercial jet fuel inventories are somewhat lower with 30 days or less supply on average.

Harbors

Harbors are critical to petroleum supply and distribution in Hawaii. While all crude oil is currently offloaded to refineries on Oahu from offshore mooring facilities at Barbers Point, most imported jet fuel and distillate fuel shipments are received at the Honolulu Harbor Complex. In addition, over 90 percent of all of the state's petroleum products pass through the Honolulu Harbor Complex for local consumption, trans-shipment to the other islands, or export. Almost all deliveries of refined petroleum products to the Neighbor Islands are by barges loaded from the Honolulu Harbor Terminals.

The new deep draft harbor at Barbers Point (serving the AES Barbers Point power plant on Oahu) will allow some on and off loading for the refineries as well as lessening dependence on petroleum by providing coal-handling infrastructure for the use of imported coal to produce electricity.

Harbors on the Neighbor Islands are equally important. Most of the Neighbor Islands have only one major harbor/terminal complex with two exceptions, Kauai and Hawaii. Kauai has two harbor/terminal areas: Nawiliwili and Port Allen. Hawaii also has two harbor/ terminal areas: Hilo and Kawaihae. However, most of the product consumed on the west side of the Island of Hawaii is not offloaded at Kawaihae Harbor but trucked to the west (Kona) side of the island.

Recent Changes Which Affect the Petroleum Industry

Recent regulatory changes and economic trends have had the effect of downsizing or changing the petroleum supply and distribution infrastructure in Hawaii. In some cases these changes may limit system flexibility and the ability to respond in the most efficient manner during a supply emergency. Major changes include:

- A 16 percent decrease in the number of service stations operating in the islands since 1992. This decrease is attributed in part to costly underground tank leakage standards imposed by the Environmental Protection Agency. The remaining stations tend to be more automated, higher volume outlets.
- The barging of heavy fuel oil to the Neighbor Islands may be curtailed by the Oil Pollution Act of 1990 (OPA-90), which poses unlimited liability for heavy oil spills. Lighter diesel fuel is currently being substituted for heavy fuel for electric power generation on the Island of Kauai and perhaps in the near future on other Neighboring Islands. This substitution will result in significantly higher electric rates for consumers on the Neighboring Islands.
- The Honolulu Waterfront Development Plan may result in the relocation of most petroleum facilities from Honolulu Harbor to Barbers Point. The uncertainty associated with this plan could result in deferred planning and delayed decisions on capital investments necessary to meet any increased petroleum and/or electric power demands.

III. Hawaii Gas Systems

There are no natural gas wells or natural gas production facilities in the State of Hawaii. The existing gas systems on the islands use synthetic natural gas (SNG) and liquified petroleum gases (LPG) produced on Oahu or imported.

SNG, produced by BHP's subsidiary ENERCO (collocated with the BHP refinery at Barbers Point on Oahu) is distributed by pipeline to residential and commercial customers on Oahu. ENERCO receives petroleum gases extracted from crude oil and other refining processes at the BHP refinery and strips out the lightest gases. SNG is distributed to residential customers in the Honolulu area by pipeline by BHP Gas Company, BHP's subsidiary distribution company on Oahu. Because the climate is temperate, there is very little demand for home heating; the primary use for SNG in residential use on Oahu is for hot water and cooking.

Both Chevron and BHP produce LPG (primarily propane, but with some ethane and butane) at their refineries. LPG is distributed in pressure tanks by truck on Oahu and by barge to Neighboring Islands. On Oahu, Hawaii, Kauai, and Maui LPG is distributed by pipeline to some residential customers. A majority of the LPG is distributed by truck to stationary cylinders at residences.

From Oahu, LPG is delivered to storage terminal facilities on the Neighbor Islands by barge. LPG barges are loaded at the deep water terminal at Barbers Point. There are four LPG barges and one other multi-use barge that carries LPG pressure cylinders. LPG is distributed from storage terminal facilities on the Neighbor Islands to residential and commercial customers by truck.

IV. Hawaii Lifeline Infrastructure

The proposals for improving critical lifeline services addressed in this hazard mitigation report are largely based upon discussions with the various companies, communities, and county and local government entities. Many of the lifeline services, issues, and problems identified are either beyond the scope of this study or do not have direct application to energy. However, they are too important not to be addressed. The areas of concern include:

Telecommunications:

- With the exception of the Islands of Hawaii and Molokai which have satellite communications, the Neighbor Islands are still very dependent on Oahu for outside communication. In the event of a major emergency in the Honolulu area affecting the communication infrastructure, most of the Neighbor Islands would be without communication.
- Only one-third of the cellular relay stations on Oahu have emergency backup generation in case of commercial electric power failure. In many instances, backup generators are precluded because of noise restrictions and/or Fire Department regulations.

Fire - Police - Medical:

- Fire Department officials on Molokai were concerned that a tidal wave from the southwest would destroy the wharf and associated fuel tanks. They felt the tanks (including the LPG tanks) represented both a fire and environmental hazard and should be relocated.
- Kidney dialysis patients at centers throughout the State would most likely have to be relocated to Honolulu in the event of a commercial electric power outage or water shortage. While Oahu is not immune from energy and other infrastructure dislocations, because of its greater population, it has more resources to draw upon and is more able to cope with these dislocations than the Neighbor Islands.
- Hospital staff members also indicated that limited on-site supplies of food, compressed gases (oxygen,etc.) and the continued operation of laundry support facilities could also be potential problem areas.

Food Supply:

- Food storage warehouses serving all Neighbor Islands are concentrated on Oahu. One of the largest suppliers, which accounts for 50% of Islands' food supply, has no on-site backup generator or fuel supply for distribution vehicles.
- Uninterrupted electric and water supplies and functioning cooling towers are required for food storage warehouses to maintain refrigeration.
- It requires approximately 5 days for ocean borne cargo to be shipped from the West Coast to the Hawaiian Islands. Additional days would be required for loading, unloading, and distribution of food supplies.

Waste Water Treatment:

- Immediately following Hurricane Iniki telecommunications on Kauai were almost nonexistent. The lack of telecommunications was a major problem for the waste water treatment plant on Kauai. The plant could not determine which employees would be able to report to work and had difficulty determining the extent of water treatment problems across Kauai. They would like to be included in the county's emergency radio communication system.
- Following Hurricane Iniki many water supply pumps and waste water lift stations on Kauai did not have emergency generators. Some of the pumps and lift stations with generators ran out of fuel. Providing fuel for these emergency generators was a problem. Local distributors were sometimes too busy to provide small quantities of fuel to distant and/or remote locations. The numerous small and/or private water and sewage treatment

facilities on Kauai compounded this deficiency. This problem is representative of what could occur under similar circumstances (hurricane, earthquake, etc.) on the other Neighbor Islands.

Water Supply:

- There is concern that hurricanes, earthquakes, and other hazards, could break water lines and drain reservoirs. This did happen in some locations on Kauai following Hurricane Iniki. Maui Water Supply has instituted new procedures to minimize the potential for water losses. These procedures consist of:
  1) warning customers prior to an event such as a hurricane that water will be shut off at a certain time,
  2) advising customers to fill bathtubs and storage containers with water,
  3) turning off the water valves at or as close as possible to storage tanks, and
  4) requesting individuals to bring containers to be filled with potable water to water supply storage tanks until normal service can be restored.

Energy Industry Hazard Mitigation Proposals

Proposals for Hawaii's Electric Industry

ELECTRIC PROPOSAL I

Increase the Fuel Storage Recoverable Under the Utility Rate Base from 30 to 35 Days.

Description The Hawaiian Electric Company (HECO) has requested an increase from 30 to 35 days in the amount of fuel stored in inventory which it can recover in its rate base. The Hawaii State Public Utilities Commission rejected this request.

Background All electric utilities must have sufficient generating capacity to serve customer loads, plus an additional reserve requirement of generation for various contingencies. Electric utilities on the mainland almost always have transmission interconnections with other utilities. An interconnected utility may either own generating capacity sufficient to serve customer loads, plus its reserve requirement, or contract with other utilities to supply this capacity in whole or in part. When necessary, an interconnected utility also may purchase power and energy to conserve its fuel supplies or if it has hydroelectric capacity to conserve its water supplies. Various emergency contracts and agreements between mainland utilities result in increased system reliability. Diverse power and energy transactions also reduce system operating costs. If one utility can incrementally produce power at a lower cost than another and a transmission path exists between them, it is normal for the lower cost utility to sell power and energy to the higher cost utility. Both utilities profit from the transaction.

With rare exceptions, island utilities do not have transmission interconnections to other utilities. To maintain a given level of reliability island utilities have to maintain higher reserve margins than interconnected utilities. Increased reserve margins mean the installation of additional generating capacity. These facilities are included in the utilities rate base and normally increase the cost of electricity to consumers. Island utilities normally maintain a greater number of days of fuel supply for the same reason as they maintain greater reserve margins. Island utilities cannot rely on their neighbors for assistance. Hawaii's utilities do not have off-island or island-to-island interconnections.

HAWAII

The power produced by HECO is ***all*** from oil-fired power plants burning distillate fuel oil (number 2 oil) and residual fuel oil (number 6 oil). HECO is required to use low sulfur fuels on Oahu. The number 2 and 6 fuel oils burned on Oahu must be 0.4 percent sulfur or less and 0.5 percent sulfur or less, respectively. These fuels are produced and consumed on Oahu. Similar low sulfur fuel oils are also available from the U.S. Mainland. However, unless a fuel purchase contract is in place, it could, in the worst case, require 90 days to obtain low sulfur fuel oils.

HECO fuel policy is to have a nominal 30 day supply of fuel on hand. This is the amount of fuel HECO is permitted by the Hawaii State Public Utilities Commission to include in its rate base for recovery of costs. HECO has previously requested the State Commission to increase the amount of fuel in the rate base from 30 to 35 days.

It is recommended. . .

that the Hawaiian Electric Company proposal to increase the amount of fuel included in its rate base from 30 to 35 days be reexamined by the Hawaii State Public Utilities Commission; that the Hawaiian Electric Company submit to the Hawaii State Public Utilities Commission a study addressing increased electrical reliability benefits vs. the annualized cost of holding an additional increment of fuel; and that this study and other pertinent information be used by the Hawaii State Public Utilities Commission as the basis for deciding if 5 days additional fuel should be included in the Hawaiian Electric Company's rate base.

The cost of fuel burned is normally a utility's largest single expense. The annualized incremental cost of holding 35 days of fuel rather than 30 is a far smaller expense.

Fuel supplies to the Neighbor Islands are almost entirely routed through Oahu. A shortage of fuel on Oahu would be shared by the Neighbor Islands, and it is likely that a shortage would be felt more acutely on the Neighbor Islands. In addition, all of the utilities on the Neighbor Islands have, on numerous occasions, had fuel supplies drop well below 30 days supply when rough ocean conditions delayed deliveries. Additional fuel inventories should increase electrical system reliability.

Lead Agencies Hawaii State Public Utilities Commission and the Hawaiian Electric Company

Funding To be determined by the lead agencies

Schedule As soon as possible

ELECTRIC PROPOSAL II

Diversify Hawaii's Sources of Electric Generation to Reduce Oil Dependency

Description Hawaii is highly dependent upon oil-fired generation for energy and the production of power. Diversification of the sources of generation to rely on other sources of electricity should both increase system reliability and most likely reduce future power costs.

Background As shown on TABLE II below, overall usage of petroleum to produce electricity in the United States is only 4 percent of total energy. On Hawaii almost 75 percent of electrical energy is produced using petroleum.

TABLE II.
Net Electricity Generation by Source

	U. S. [1]	Hawaii [2]
Coal	57%	15%
Petroleum	4%	74%
Gas	9%	0%
Nuclear	21%	0%
Hydroelectric	9%	Less Than 1%
All Others	Less Than 1%	10%

All Others in Hawaii includes: Biomass (4.3%), Municipal Solid Waste (3.4%), Geothermal (1.5%), Wind (0.2%), and Others (0.1%)

Oil-Fired Generation

Worldwide, electricity production on most lightly populated islands is heavily dependent upon oil-fired generation. This is essentially due to the economics of electrical generation. Oil- fired generation is available in all sizes, from a few kW to hundreds of MW. A large amount of fuel oil can be stored in a relatively small space, and oil is readily delivered by ship.

Nuclear power

Nuclear power plants typically have large generating capacities, have significant problems relating to siting and environmental approvals, and require a very large capital investment. No new nuclear plants

[1] Energy Information Administration, Electric Power Annual 1993, Issued December 1994, Page 14.

[2] State of Hawaii, *State Energy Resource Coordinator's Annual Report 1994*, Page 41.

have been started in the United States for more than a decade, and a nuclear unit is not considered a viable power supply alternative for Hawaii.

Coal-Fired Generation

Coal-fired plants also have siting problems and require a great amount of land, but are generally viable to serve the electrical requirements of utilities with more than several hundred thousand customers. At this time Oahu appears to have sufficient electric load to make a coal-fired plant a viable power supply alternative.

Gas-Fired Generation

Natural gas is an increasingly used power plant fuel on the U. S. mainland, and could be used on the Hawaiian Islands if there is an economical source of fuel. Studies indicate that importation of Liquified Natural Gas (LNG) is not a practical alternative at this time. Gas-fired generation is, like oil, available in a wide range of capacities. Hawaii does not have natural gas or gas-fired generating units, but does have synthetic natural gas. Synthetic natural gas on Hawaii is derived from petroleum. The feasibility of gas-fired generation is limited by the availability of synthetic natural gas.

RENEWABLE ENERGY RESOURCES

Municipal Solid Waste

The management of the 60 MW municipal solid waste (trash) burning H-Power plant, stated that there was, "room for a one third expansion, which is not planned at present". The actual limiting factor for a municipal solid waste plant is the availability of suitable refuse. In the past several years there has been a decrease in the amount of municipal solid waste, due perhaps to economic conditions and/or increased recycling. Currently only municipal solid waste from Oahu is used to produce electric power. However, as population and tourism grow on the Hawaiian Islands and other means of refuse disposal become more difficult and expensive, expanded and additional refuse burning plants may become more attractive.

Solar

Hawaii is well positioned geographically to utilize solar energy. However, solar energy projects produce energy without reliable electric capacity. That is, solar technology projects are supplemental. When sunlight is not available either energy storage devices or conventional generation is required as a backup. Few non-subsidized solar energy projects have been able to displace commercial electric power on a cost basis.

Biomass

Hawaii's sugar industry, and to a lesser extent the pineapple industry, are primary sources of biomass to generate electricity. The technology to produce electricity from biomass is mature and functions well.

Unfortunately, production in both of these industries are in decline and future supplies of biomass fuels are doubtful.

Hydroelectric

Hawaii has the basic requirement for hydroelectric power, areas with mountains and significant rainfall. However, the most effective use of hydroelectric power requires creation of lakes for water impoundment. Land use considerations, problems obtaining siting and environmental permits, and the high capital cost of building new facilities limit the development of hydroelectric power on Hawaii.

Geothermal

Geothermal energy appears viable on several of the Hawaiian Islands, particularly on Hawaii. However, environmental, religious, and political considerations seem to limit geothermal technology on the Hawaiian Islands.

Ocean Thermal Energy Conversion

Similar to conventional commercial power plants, Ocean Thermal Energy Conversion (OTEC) produces both energy and electrical capacity. OTEC also produces electrical energy and capacity without significant environmental impact. The principal detriment to OTEC is the high capital cost to build it. While OTEC may make a long-term contribution to Hawaii's energy requirements, in the short and medium terms, it can not be expected to be competitive.

ALTERNATIVES TO PETROLEUM

Various renewable resources can contribute to the power supply on Hawaii, and should be encouraged where economically feasible. However, with the exception of municipal solid waste, it is unlikely that a major contribution from renewable resources would significantly reduce oil consumption.

The best current non-renewable alternative for diversifying the sources of electric generation and displacing oil-fired generation appears to be coal. Coal can be stockpiled with minimal environmental risk and is being stored at Barbers Point. The coal unloading port, equipment to unload colliers, and a belt transport to deliver coal to Barbers Point already exist. The port and unloading facilities are unused most of the time and coal throughput could easily be expanded. The AES Barbers Point power plant on Oahu currently receives its coal under long term contracts from Indonesia. However, once loaded on a collier, coal can be shipped to ports anywhere in the world with very little additional cost. Utilities often purchase coal on the world market at the best available price.

The normal time to implement a plan to diversify sources of generation is when the next increment of generation is being planned to meet load growth or replace aging existing power plants. The generation selected should have the lowest life-cycle-cost for producing power and energy and should increase system reliability. The determination concerning who should build and operate the generation, HECO or an independent power producer, should be based upon considerations of cost and system reliability.

Construction of a coal-fired or a municipal solid waste plant is presently feasible only on Oahu. However, it appears that population and load growth may allow coal or solid waste units to be feasible on Maui in the near future and on other Hawaiian Islands further in the future.

It is recommended. . .

that the sources of electric generation on Hawaii be diversified to increase system reliability. Construction of new and/or expansion of existing coal-fired or municipal solid waste plants should be given strong consideration as the next increment of generation is being planned. The generation selected should have the lowest life-cycle-cost for producing power and energy and should increase system reliability. Future coal or municipal solid waste plants would reduce the dependance upon oil-fired generation on the Hawaiian Islands.

When new generation is required, it should be built and operated by either the electric utility or an independent power producer, based upon consideration of cost and system reliability.

Lead Agencies Hawaii State Public Utilities Commission, Hawaii's Electric Utilities, and independent power producers

Funding To be determined by the lead agencies

Schedule When the commitment to the next increment of generation is required

ELECTRIC PROPOSAL III

Improve the Business Climate for Electric Utilities Operating in Hawaii

Description

Industry in general, and the electrical industry in particular, have to make long-term investments. The capital recovery period for a major generation investment is normally 30 to 40 years. Electric utilities require a predictable business climate which permits recovery of their investment costs. Without a reasonable expectation that it can recover its capital costs and achieve an adequate return on its investments utilities can not reasonably be expected to make capital improvements needed to increase system reliability or for environmental compliance and/or improvements.

Background

Pressures to Relocate Electrical Facilities

Almost all generating facilities, fuel storage areas, and fuel terminals on the Hawaiian Islands are located in coastal areas. Many terminal operators and other businesses with facilities currently located in the Honolulu Harbor area may be displaced by the Honolulu Waterfront Redevelopment Plan. At the same time, these operators and businesses are subject to new environmental and other regulations from the state and federal governments that require substantial financial investments.

The State of Hawaii has requested HECO to relocate the 100 MW Honolulu Harbor power plant. HECO would like to operate this plant through 2010. Relocating this power plant does not make economic sense. A realistic alternative would be to scrap the Honolulu plant and build a new power plant, or purchase power from another source. In addition, the present location of the power plant is important electrically for maintaining proper voltage in the Honolulu area. Elimination of the Honolulu Harbor power plant would require considerable change to the HECO transmission system and substantial additional costs for HECO.

Recovery Following Hurricane Iniki

Citizens Utilities Co. utilized enormous amounts of replacement equipment, spare parts, machinery, and manpower in recovering from the damage to its system on Kauai caused by Hurricane Iniki. The funds needed for these expeditious repairs would almost certainly not have been available if Kauai Electric had not been a part of Citizens Utilities. In addition, Citizens Utilities currently has three programs to improve the resiliency of its transmission and distribution systems. It is spending approximately $20 million to replace wood poles with steel poles, spending $300,000 a year to install guy wires on those wood poles not being replaced with steel poles, and is closing distribution system loops, improving fuse coordination, and scrutinizing its transmission and distribution protection schemes.

Citizens Utilities requested, and the Legislature of the State of Hawaii passed, a bill authorizing the Public Utilities Commission to charge electricity rate payers on Hawaii a dollar a month towards the disaster recovery on Kauai. The PUC has not approved the measure. The rationale for this method of cost recovery is clear. The costs of the recovery were so great that Citizens Utilities can not recoup its costs from the rate payers of Kauai in any reasonable time. The ratepayers on any Hawaiian Island, except Oahu, would similarly be unable to repay the recovery costs of a major disaster without outside assistance.

The rejection of the $1/month assessment is very likely to slow restoration of power on the Hawaiian Islands following a hurricane, earthquake, extreme winds or other event. The principal determinant of the duration of restoration of power following a disaster is decided by the number of repair crews and equipment brought in from other utilities. However, the use of outside repair crews and equipment greatly increases the cost of repairs. Rebuilding transmission and distribution lines to withstand greater wind loadings also increases costs. The rejection of the tax by the Hawaii Public Utilities Commission will almost certainly delay restorations of power in the future and retard upgrading of transmission and distribution facilities.

Energy Industry Perceptions

The actions of the Federal Government, the State of Hawaii, and the Hawaii Public Utilities Commission sends a message that Hawaii is not friendly to energy-related businesses. A second clear message is that the costs of disaster recovery are likely to be paid for by the utility share holders, not the ratepayers. These actions may adversely affect the ability of utilities on Hawaii to attract sufficient capital to procure new electric power facilities.

It is recommended. . .

that meetings including the Governor's Energy Emergency Preparedness Advisory Committee, Hawaii State Public Utilities Commission, Department of Business Economic Development & Tourism (DBEDT) Energy Division, the Hawaiian Electric Company, and the Kauai Electric Division of Citizens Utilities Co. be initiated to explore ways to improve lines of communication and ameliorate the uncertainties of operating an electric utility in Hawaii.

Lead Agencies Governor's Energy Emergency Preparedness Advisory Committee, Hawaii State Public Utilities Commission, Department of Business Economic Development & Tourism (DBEDT) Energy Division, the Hawaiian Electric Company, and the Kauai Electric Division of Citizens Utilities Co.

Funding To be determined by the lead agencies

Schedule As Soon As Possible

ELECTRIC PROPOSAL IV

Interconnect the Electric Systems on Maui, Molokai, and Lanai with Underwater Transmission Lines

Description The Islands of Maui, Molokai, and Lanai are relatively close together. Transmission lines connecting the three islands would allow construction of larger generating units taking advantage of economies of scale. At present, Molokai has a 2.5 MW diesel-fueled combustion turbine and six 1.1 MW diesel generators. Lanai has eleven diesel generators, producing about 10 MW.

Background The peak electric load on Maui is sufficient to provide considerable flexibility in selecting future electrical generation. Power on Maui is currently produced using oil-fired generation, supplemented by firm and standby power purchases from sugar plantations and hydroelectric facilities. In the future, Maui Electric Co. may be able to utilize coal or municipal solid waste burning power plants to reduce dependance on oil-fired generation and also reduce power costs. As shown in TABLE III below, peak demand on Lanai and Molokai are 4.7 and 6.4 MW respectively. The generation normally used to meet loads of this size include oil or natural gas-fired diesels, agricultural waste-fired generation, and small hydroelectric plants. The demand is too small to provide much flexibility in future electrical generation.

TABLE III.
Load and Generation

	Lanai	Molokai	Maui
Existing Generation	10.8 MW	9.1 MW	213 MW *
1994 Peak Load	4.7 MW	6.4 MW	163 MW

* Includes firm power purchases

Installing underwater transmission lines between Maui, Molokai, and Lanai would effectively make them a single electrical entity. These connections would allow the Islands of Molokai and Lanai to be served by larger, more efficient generating units than at present. The economic benefits to Maui of such an interconnection would be slight, and there would be some risk that electrical problems on Molokai or Lanai could cause an electrical outage on Maui.

A study was made of the cost of the underwater cables necessary to interconnect Maui, Molokai, and Lanai. The cost was estimated to be $90 million. At first inspection this appears to be far more than the expected benefits resulting from the interconnection.

Benefit/Cost Analysis

Assumptions:
1. The lifetime of an underwater cable is 30 years.
2. The overall cost of money for Maui Electric Co. is 14%.

$$\text{Capital Recovery Factor (CRF)} = \frac{i \times (1 + i)^n}{(1 + i)^n - 1}$$

i = interest rate of 14%
n = the period of 30 years

$$\text{CRF} = \frac{14\% \times (1 + 14\%)^{30}}{(1 + 14\%)^{30} - 1}$$

$$\text{CRF} = 14.28\%$$

Annualized cost of
an underwater cable = $90 Million X 14.28% = $12.852 Million

The total billing for electricity on Molokai and Lanai for 1993 was $3.7 and $5.5 million,[3] respectively. Any savings would have to come out of the total annual cost of electricity on Molokai or Lanai and would be a fraction of this total cost. Since the annualized cost of an underwater cable is more than the $9.2 million total cost of electricity, this proposal is not cost effective. It is also far too expensive to be recommended based upon any improvements to electrical system reliability on Molokai and Lanai.

This proposal is not recommended.

[3] The State of Hawaii Data Book 1993-94, A Statistical Abstract, Page 385.

ELECTRIC PROPOSAL V

Convert Existing Overhead Transmission Lines on Oahu to Underground Lines

Description

Above ground transmission and distribution facilities are highly vulnerable to hurricane damage. Underground power lines are far less vulnerable to wind damage.

Background

Electric utilities tend to place transmission lines underground in highly urbanized areas. The primary reasons for this are the difficulty in securing rights-of-ways and safety problems operating above ground power lines in crowded urban areas. In rural regions and most suburban areas overhead transmission lines are used.

Based on the experiences of other electric utilities, installation of underground electrical services is much more expensive than overhead lines, and can result in reliability problems beginning 10 to 15 years after installation.

Hawaii Electric Company provided lists of actual and projected costs for building overhead transmission lines and for converting overhead transmission lines to underground lines. Due to the varied geography of Oahu and the urban, suburban, and rural areas in which transmission lines run, the per mile cost of constructing the transmission lines varies greatly. The per mile cost of constructing new 138 kV overhead transmission lines vary from a low of $301,000/mile, to a high of $2,954,000/mile, almost a 10 to 1 difference. The per mile cost of converting overhead 138 kV transmission lines to underground lines vary from $1,101,000/mile to a high of $15,000,000/mile, more than a 13 to 1 range.

Because of the extreme range in construction prices for both overhead and underground transmission lines, only direct comparisons of the costs of overhead and underground transmission lines along the same route is valid. Fortunately this information is available for 2 transmission lines, the 2.8 mile Kalaeloa-CEIP line and the 4.5 mile Waiau-Makalapa #2 line. The 2.8 mile Kalaeloa-CEIP line cost $843,150 to build as an overhead line. HECO estimates that it would cost $42,000,000 to convert the Kalaeloa-CEIP line to an underground service. The 4.5 mile Waiau-Makalapa #2 line cost $13,291,423 to build as an overhead line. HECO estimates that it would cost $54,000,000 to underground the Waiau-Makalapa #2 line.

For purposes of this study an expected lifetime of 30 years has been assumed for underground transmission lines. The recurrence interval for Hurricanes on Oahu is 50 years. The significance of these numbers is that, on Oahu, an underground transmission line can be expected to wear out and require replacement more often than an overhead transmission line would need repair or replacement due to a hurricane. Since the cost of the underground line is 10 or more times the equivalent overhead line, this conversion can not be recommended on either a benefit/cost or reliability basis.

This proposal is not recommended.

ELECTRIC PROPOSAL VI

Close Radial Transmission Line Loops on Oahu and Kauai

Description The Island of Oahu and to a lesser extent the Island of Kauai have radial feed transmission lines which can be looped or closed.

Background A radial feed transmission line is inherently less reliable than a looped or closed line. A single failure on a radial transmission line may cause an outage for everyone served by that line. After a fault is isolated all customers downstream of the fault would be deenergized until the fault is repaired. With a radial feed, the immediate area of the fault is electrically isolated and customers receive power from both ends of the line. All of the customers on that line, except for the small number of customers very close to the fault would have power while repairs are made. The principal disadvantage of a radial feed is the additional financial and environmental cost of constructing the transmission line to close the loop.

It is recommended. . .

for public safety that the Hawaiian Electric Company and the Citizens Utilities evaluate the radial feed transmission lines on Oahu and Kauai to determine which should be looped to increase system reliability. Priority should be given to looping any radial feeds serving critical lifeline facilities. The evaluations should be made on a case by case basis, with the increased reliability weighed against the financial and environmental costs. No recommendations can be made in this study for specific transmission line loops.

Lead Agencies Hawaii State Public Utilities Commission, Department of Business Economic Development & Tourism (DBEDT), Energy Division, the Hawaiian Electric Company, and the Kauai Electric Division of Citizens Utilities Co.

Funding Expenditures would be made by the Hawaiian Electric Company and the Kauai Electric Division of Citizens Utilities Co. subject to cost recovery through each utility's rate bases.

Schedule As Soon As Possible

ELECTRIC PROPOSAL VII

Utilize Ocean Water for Power Plant Cooling Water Requirements—Eliminate Vulnerable Cooling Towers

Description

The H-Power, Kalaeloa Partners, and AES Barbers Point power plants on Oahu are all thermal generating units. Each of the power plants gets make-up and cooling water from on site wells and recirculates cooling water through wooden cooling towers, and reuses the water for cooling. After the system starts, well water is drawn only to replace water losses. Wooden cooling towers such as these have proven highly vulnerable to hurricane or gale force winds. The loss of a cooling tower could currently cause each of the plants to shut down. It is proposed that the cooling systems at each of the three power plants be converted to use a once-through cooling system, i.e., with cooling water being taken from each of the three underground wells, a single use cooling each power plant, and being sent to an ocean outfall shared by all three power plants.

Background

The Hawaiian Electric Co. Inc. (HECO) owns a total of 1,263 MW of electrical generation on Oahu,[4] HECO purchases an additional 420 MW of power, more than 26 percent of its total capacity. The purchased power comes from the 60 MW municipal solid waste burning H-Power plant, 180 MW from the number 6 oil burning Kalaeloa cogeneration plant, and 180 MW from an independent power producer, the AES Barbers Point coal-fired unit. The H-Power, Kalaeloa, and AES power plants all have wooden cooling towers which appear highly vulnerable to hurricane winds. The loss of a cooling tower could currently cause each of the plants to shut down. During periods of high winds, the salt water spray from the cooling tower can cause additional problems and has caused short circuits at the AES electrical station.

The cooling systems for these three power plants consists of recirculating water cooling towers with makeup water supplied from adjacent wells. This type of system is normally used to minimize the consumption of fresh water and less often used when the water supply is brackish well water. These three power plants are adjacent to the Pacific Ocean and since the water consists primarily ocean water, there is only a slight effect of conserving fresh water resources.

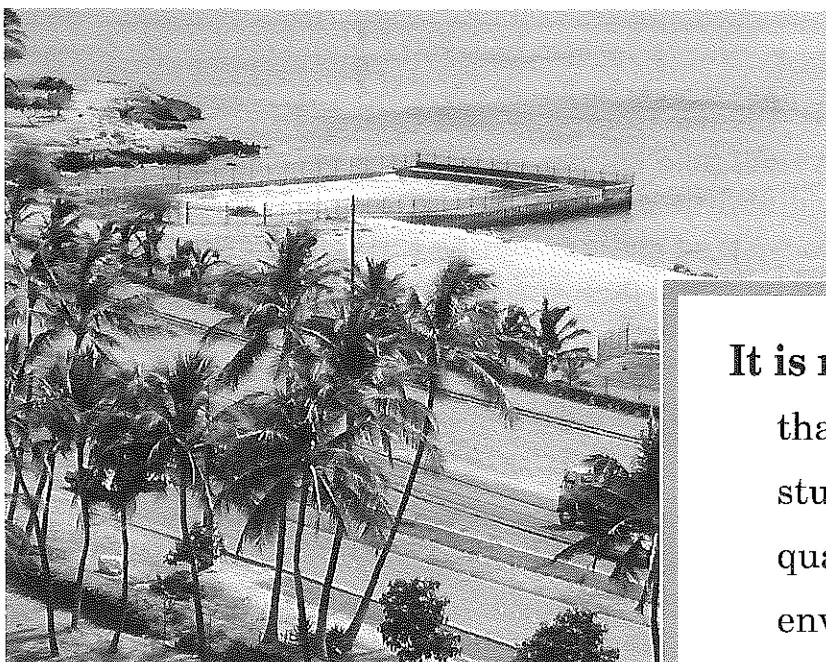
The use of an ocean outfall, such as used by Citizens Utilities on Kauai and several HECO power plants on Oahu, Maui, and Hawaii,

[4]Letter to the Hawaii Public Utilities Commission, from the Hawaiian Electric Company, Inc., dated January 31, 1995.

would reduce vulnerability of these three power plants to hurricane and gale force winds. In addition, it appears that the three facilities could share a common outfall.

Using a once-through cooling system, the discharge water warms the water in the outfall. The amount of this warming and the effects upon the local marine environment should be determined before any changes to the cooling systems are made. The outfalls observed at other Hawaiian power plants are effectively used as holding tanks. The warmed cooling water is injected into one end of the outfall. The other end of the outfall is partially opened to the ocean. Ocean and cooling water mix in the outfall, moderating the temperature increase of the water entering the ocean from the outfall.

The use of an outfall can be expected to have several beneficial effects. It will significantly reduce the vulnerability of the three power plants to high winds and increase system reliability. Elimination of the cooling towers would reduce overall maintenance costs and energy would be saved by not having to operate the cooling tower pumps. To the extent that once-through cooling reduces water temperatures, the operating efficiencies of the power plants should be higher and fuel consumption somewhat reduced.



Ocean Water Outflow at a Hawaiian Electric Company Power Plant on Oahu.

It is recommended... that this proposal be studied in greater detail to quantify the benefits and environmental impacts.

Lead Agencies The owners of the H-Power, Kalaeloa, and AES power plants and state and federal environmental protection authorities

Funding To be determined by the lead agencies

Schedule To be determined by the lead agencies

ELECTRIC PROPOSAL VIII

New Transmission Lines Constructed on Kauai and Sections of Oahu and Hawaii Subject to Hurricanes and Extreme Winds Should Consider Alternatives to Wood Structures.

Description Hurricanes and extreme wind events have caused failures of single transmission towers and entire sections of transmission lines constructed with wood poles. A steel pole/structure option should be fully evaluated for new construction of transmission lines subject to hurricanes and extreme winds.

Background Wood pole structures during hurricanes (such as Iniki and Andrew) have performed poorly. Steel pole structures have had a much higher survival rate. The cost of steel poles at the transmission voltages used on Hawaii would be equal to or marginally higher than a wood pole option, but with a significant increase in structural reliability.

It is recommended...

that the Hawaiian Electric Company and Citizens Utilities evaluate steel pole transmission lines to increase system reliability. Priority should be given to transmission lines serving critical lifeline facilities. The evaluations should be made on a case by case basis, with the increased reliability weighed against the financial and environmental costs. No recommendations can be made in this study for specific transmission lines.

Lead Agencies Hawaii State Public Utilities Commission, Hawaiian Electric Company, and the Kauai Electric Division of Citizens Utilities Co.

Funding Expenditures would be made by the Hawaiian Electric Company and the Kauai Electric Division of Citizens Utilities Co. subject to cost recovery through the utility's rate bases.

Schedule As Soon As Possible

ELECTRIC PROPOSAL IX

Many Power Lines on the Hawaiian Islands Were Constructed to Withstand Lower Wind Speeds than Current Design Requirements. Existing Power Lines Serving Critical Lifeline Facilities Should Be Upgraded as Necessary to Withstand Minimum ANSI/ASCE-7 Wind Loading.

Description Older transmission/subtransmission and distribution lines were not engineered to survive the currently assessed level of natural hazards. Therefore, critical structures within these lines may not have the capacity to resist potential hurricane and extreme wind loads.

Background The majority of electric utility systems consist of older design transmission lines. As more information on structural loading becomes available design standards are upgraded. It is too costly for a utility to upgrade all of their facilities to update design loads. One cost effective means for hardening existing distribution, transmission/subtransmission lines is to upgrade the structural capacity of selected towers within the line. Most existing towers do not utilize their full structural load capacity. Their actual wind and vertical load spans are less than the maximum used in the original designs. Significant benefits can be obtained by upgrading critical towers within an older line. These benefits include maintaining operation and quicker recovery from a natural hazards event.

One option to upgrade existing structures is the installation of storm guys and push-poles. The structural load carrying utilization of structures within a line can be evaluated. Unused structural capacity can be taken into account for upgrading structures to high loads. Structures located on critical power delivery lines (both distribution and subtransmission lines) requiring additional structural load capacity should have storm guys and push-poles. Distribution lines on coastal areas should be fitted with storm guys and/or push poles when land use allows for their installation. When this means of upgrading a structure is inadequate to satisfy the new loads (minimum ANSI/ASCE-7) the structure should be replaced.

It is recommended. . .

that the Hawaiian Electric Company utilities and Citizens Utilities evaluate critical structures and coastal transmission lines to determine which should be upgraded to increase system reliability. Priority should be given to lines serving critical lifeline facilities and coastal areas. The evaluations should be made on a case by case basis, with the increased reliability weighed against the financial and environmental costs. No recommendations can be made in this study for specific transmission line loops.

Lead Agencies Hawaii State Public Utilities Commission, Department of Business Economic Development & Tourism (DBEDT) Energy Division, the Hawaiian Electric Company, and the Kauai Electric Division of Citizens Utilities Co.

Funding Expenditures would be made by the Hawaiian Electric Company and the Kauai Electric Division of Citizens Utilities Co. subject to cost recovery through the utility's rate bases.

Schedule As Soon As Possible

ELECTRIC PROPOSAL X

General Order No. 6, (GO6) Rules for Overhead Electric Line Construction Specifies Minimum Overhead Power Line Structural Loading Requirements. The Requirements of GO6 Should Be Upgraded to Withstand Current and Subsequent ANSI/ ASCE-7 Minimum Wind Loading

Description The State of Hawaii's General Order No. 6 establishes the minimum design level for electric power distribution and transmission facilities. The requirements provide electric power facility designs that satisfy an acceptable level of public safety.

Background GO6 and similar documents are developed for the purpose of establishing a design that satisfies a minimum public safety level. Many times this type of document is used as the maximum design level. Constructing power lines to satisfy GO6 minimum requirements, rather than to resist expected natural hazards may significantly reduce overall system reliability.

Code requirements relating to structural loading and strength criteria are normally revised periodically, usually upgrading minimum requirements. ANSI/ASCE-7 for example is revised on a five year cycle. General Order No. 6 (GO6) was approved by the State of Hawaii on February 27, 1969. GO6 should be raised to require new distribution and transmission facilities withstand higher hazard level than its current requirements. As a minimum this criteria should meet the current ANSI/ASCE-7 standard.

A significant portion of the transmission and distribution facilities on Hawaii have been built to the current level of GO6. Existing transmission and distribution facilities important to overall system reliability and/or serving critical lifeline facilities should be upgraded, but not necessarily to current ANSI/ASCE-7 levels. This would be too costly. However, it is recommended that design criteria less stringent than the current ANSI/ASCE-7 be used for upgrading facilities. Typical upgraded design levels are 80 to 90 percent of that required for ANSI/ASCE-7 new construction.

It is recommended...

that the structural loading and strength requirements be reviewed and upgraded to increase system reliability and maintain public safety. The requirements should address both new construction and acceptable levels for upgrading existing power lines.

Lead Agencies The Hawaii State Public Utilities Commission, Department of Business Economic Development & Tourism (DBEDT), Energy Division, the Hawaiian Electric Company, and the Kauai Electric Division of Citizens Utilities Co.

Funding Expenditures would be made by the Hawaiian Electric Company and the Kauai Electric Division of Citizens Utilities Co. subject to cost recovery through the utility's rate bases.

Schedule As Soon As Possible

ELECTRIC PROPOSAL XI

Wood Poles in Tropical Areas Such as Hawaii Should Be Inspected at Least Every 5 Years and Replaced or Repaired as Necessary to Current ANSI/ASCE-7 Wind-Loading Standards.

Description Wood poles can decay over time and result in significant reduction in structural load capacity. This is a typical problem for utilities providing power in wet environments that tends to accelerate the decay at the groundline interface of the pole foundation. The frequency of inspection should be based on severity of the environmental conditions that accelerate wood decay and the consequence of reduced structural capacity when subjected to hurricanes, earthquakes, and other natural hazards. The failure of these structures will result in the loss of power distribution and can significantly hinder first responders by blocking transportation routes. Wood poles with reduction in structural load carrying capacity should be replaced.

Background Utilities have established inspection programs to detect wood decay of poles. The frequency of the inspection program can vary for different utilities. Utilities in wet environments that are subjected to frequent natural hazards should have a more active program. Wood pole decay can reduce the structural capacity of wood poles. Failed poles along transportation routes can prevent access to emergency response personnel as well as the loss of providing electric power to critical facilities. Poles that have reduced structural capacity should be replaced at the earliest possible time. Power lines serving lifeline facilities and along lifeline transportation routes should have a shorter inspection interval and a higher priority for replacement.

It is recommended. . .

for improved system reliability that the Hawaiian Electric Company and the Citizens Utilities maintain an active program of wood pole inspection to identify weak distribution and subtransmission poles for replacement. Priority should be given to lines serving critical lifeline facilities and lifeline transportation routes.

Lead Agencies The Hawaiian Electric Company, and the Kauai Electric Division of Citizens Utilities Co.

Funding Expenditures would be made by the Hawaiian Electric Company and the Kauai Electric Division of Citizens Utilities Co. subject to cost recovery through each utility's rate base.

Schedule As Soon As Possible

ELECTRIC PROPOSAL XII

Electric System Distribution Structures Shared with Communications Utilities May Be Overloaded, Adversely Affecting the Reliability of Distribution Circuits. The Structural Adequacy of Distribution Structures to Withstand Such Attachments Should Be Determined Prior to Communications Cable Installation

Description

It is common utility practice to allow the joint use of electrical distribution poles by telephone and cable TV companies. These additional cables can reduce the structural load capacity of the distribution pole. There is no mandatory requirement that the poles be assessed to determine the resulting structural load levels. The additional cables can cause a reduction in the pole structural capacity and premature failure during a hurricane, earthquake, or other natural phenomena hazard.

Background

The structural capacity of a distribution pole is determined by the vertical weight and projected wind area of the supported wires/cables. Unless the original design of the pole accounts for additional utility wires, there will be a reduction in structural capacity of the pole. This can result in the premature failure during a natural phenomena hazard event. If the distribution line is adjacent to a transportation route these failures can block access by emergency personnel. Hurricane Iniki caused power poles to fail, blocking transportation routes on Kauai. These failures may not have been caused by joint use access but the consequence of blocked transportation routes would be the same. To minimize premature failure an engineering review of proposed joint use cable installations should be conducted to determine the structural load carrying capacity of the distribution pole. This should be required for critical distribution lines servicing lifeline facilities. When distribution poles have the potential of disrupting lifeline transportation routes for emergency first responders that line should also be assessed before additional cables are installed for joint use.

It is recommended. . .

for public safety that the Hawaiian Electric Company and the Citizens Utilities establish a policy for reviewing the structural capacity of distribution lines for the addition of other utility wires. Priority should be given to distribution lines serving critical lifeline facilities and lifeline transportation routes.

Lead Agencies Hawaii State Public Utilities Commission, the Hawaiian Electric Company, and the Kauai Electric Division of Citizens Utilities Co., Telephone Company and Cable TV Utilities

Funding Expenditures would be made by the Hawaiian Electric Company and the Kauai Electric Division of Citizens Utilities Co., Telephone Company and Cable TV Utilities subject to cost recovery through each utility's rate base.

Schedule As Soon As Possible

ELECTRIC PROPOSAL XIII

All Electric Utilities on Hawaii Should Have Current and Complete Emergency Operating Plans. These Plans Should Be Exercised Both Internally and in Conjunction with the State of Hawaii and Other Lifeline Entities

Description The continuous availability of electric power is critical to any modern society and the operation of lifeline services. Rapid and effective response to energy emergencies is enhanced by the development and exercise of emergency plans. These documents provide the procedures by which a utility recovers from a natural disaster. Exercising the plan allows for identifying potential problems in recovery procedures and communications, both internally and externally.

Background All organizations operating electrical lifeline systems should develop and maintain a current emergency operation and recovery plan. The plan should be exercised on a frequent basis to allow key personnel to maintain proficiency in the plan procedures and to test communications between first responders and recovery crews.

It is recommended. . .

for public safety that the Hawaiian Electric Company and the Kauai Electric Division of Citizens Utilities develop and/or finalize emergency response plans and conduct regular emergency practices to test the plan procedures.

Lead Agencies Hawaii State Public Utilities Commission, the Hawaiian Electric Company, and the Kauai Electric Division of Citizens Utilities Co.

Funding Hawaiian Electric Company and the Kauai Electric Division of Citizens Utilities Co.

Schedule As Soon As Possible

ELECTRIC PROPOSAL XIV

Implement Hazard Mitigation Measures to Improve Electric Utility Operations:

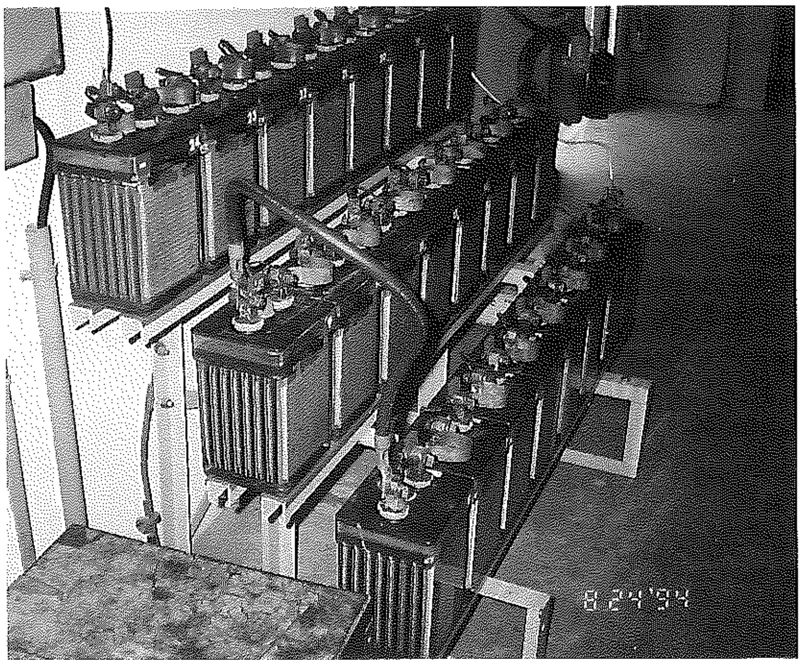
Description A number of hazard mitigation measures have been included in this electrical proposal to increase the resiliency of electric utility facilities and equipment following earthquakes, extreme winds, and hurricanes. These mitigation requirements provide a high benefit/cost ratio. They should be applied to new construction and existing facilities.

Background As a result of extensive interviews with plant operators, dispatchers, and transmission maintenance and design personnel on Hawaii and mainland utilities, the following mitigation options have been identified:

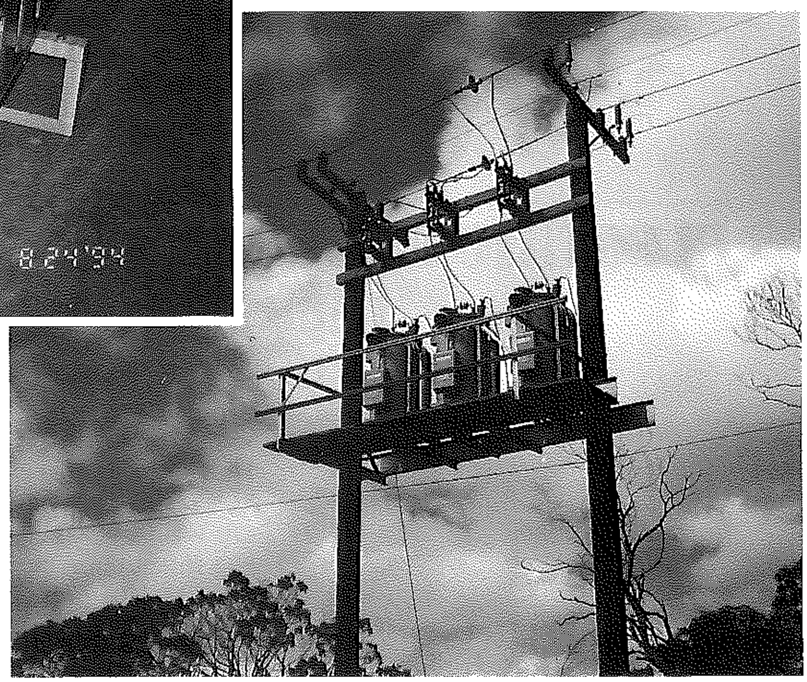
XIV-A Anchor Transmission and Distribution Transformers and Harden Batteries

Background At substations and generation facilities on the Hawaiian Islands subject to earthquakes: restrain batteries and install battery spacers. Failure of battery systems can result in the loss of function of an electric power facility. The purpose of battery systems is to provide short term power for the continuous operation of critical components.

The batteries are required until commercial power is restored or emergency generators are put on line. Batteries that are not anchored/restrained can spill their contents which can result in a hazardous material cleanup. This can cause significant delays in recovery time.



Unanchored / Unrestrained Batteries



Platform Mounted Distribution Transformers

Unanchored and improperly anchored pole, platform, and pad mounted distribution transformers can significantly reduce the reliability of the distribution system. Better restraining and bolting of pole and platform mounted distribution transformers can prevent the loss of power to customers and lifeline facilities.

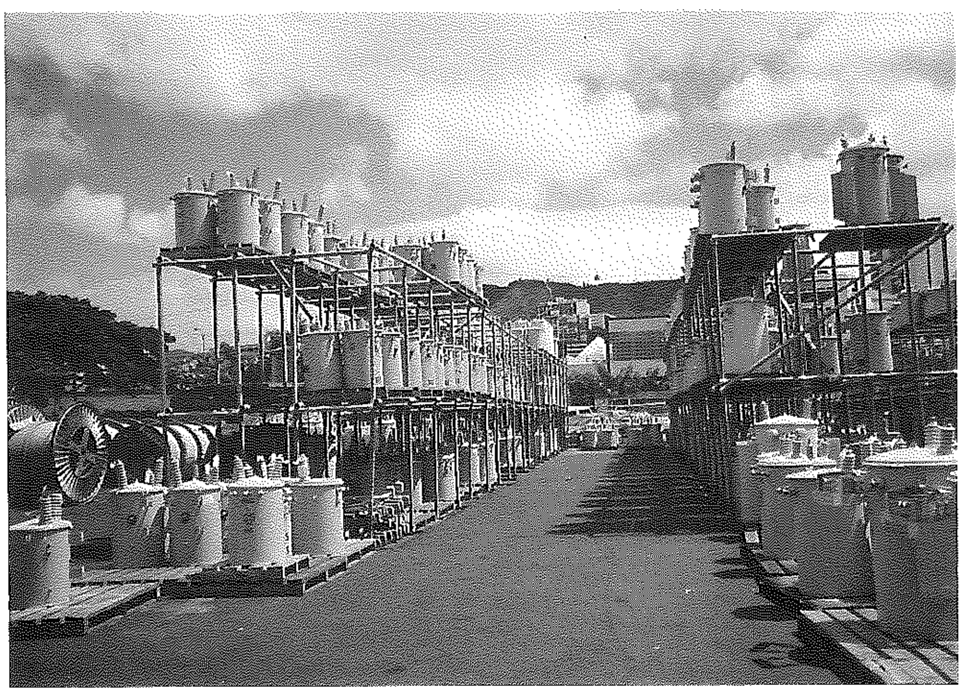
Improved anchoring of pad mounted transmission and distribution transformers will prevent the loss of this equipment as a result of sliding and/or overturning under earthquake conditions.

XIV-B Provide Flexible Equipment Connections

Background Inadequate connection flexibility between electrical equipment and structures can cause failures during earthquake and extreme wind events. The relative movement between components should take into account both static and dynamic loading. Adequate flexibility and/or slack should be provided in the connections between equipment/ structures. Equipment interaction should be considered for new construction and upgrading of existing equipment should be evaluated to increase system reliability.

XIV-C Maintain and Harden Spare Equipment Storage

Background Emergency equipment stored both indoors and outdoors should be hardened to prevent loss during an earthquake or hurricane. The equipment and storage racks should be anchored and designed to survive the natural hazard. Buildings used to store emergency equipment should be designed and constructed to be capable of surviving expected hurricane and earthquake loadings.



Outdoor Storage of Distribution Transformers

Each island should maintain an appropriate level of emergency spare equipment. If multiple islands are subjected to a significant event, such as Hurricane Iniki, each island will initially have to provide its own recovery resources. An evaluation of the emergency spare equipment storage levels should be made based on the requirements of short term recovery of the individual islands and long term recovery of the islands as a system.

It is recommended. . .

for public safety and system reliability that the Hawaiian Electric Company and the Kauai Electric Division of Citizens Utilities Co. implement the above mitigation measures for hardening electric power facilities.

Lead Agencies Hawaiian Electric Company, and the Kauai Electric Division of Citizens Utilities Co.

Funding Expenditures would be made by the Hawaiian Electric Company and the Kauai Electric Division of Citizens Utilities Co. subject to cost recovery through the utility's rate bases.

Schedule As Soon As Possible

ELECTRIC PROPOSAL XV

Wind Speed Studies Be Conducted on the Hawaiian Islands to Determine the Appropriate Wind Loading Requirements for Electrical Facilities

Description Large amounts of money are spent by electric utilities and others to construct facilities to withstand assumed design wind loadings. A study of wind speeds may reveal that facilities need to be built to more stringent standards. The cost of a wind study is several orders of magnitude less costly than the amounts spent designing, constructing, and maintaining energy facilities.

Background Hawaii's unique topographical features can significantly affect the wind loads on electrical lifeline systems. The design wind speed can be significantly increased by the topographical features. To determine the affects of topographical features on hurricane and extreme wind loads a wind field measurement and/or wind tunnel study should be conducted. Design wind speeds should take into account the mountainous features. A long term wind field measurement project should be conducted to study and identify special wind requirements for the islands. Short term boundary layer wind tunnel studies should be considered for each island.

It is recommended...

for system reliability that the Hawaiian Electric Company and the Kauai Electric Division of Citizens Utilities Co. conduct a wind field measurement and/or wind tunnel study of the Hawaiian Islands to determine the affects of the unique topographical features on design wind speeds used for electric lifeline system facilities.

Lead Agencies Hawaiian Electric Company, and the Kauai Electric Division of Citizens Utilities Co.

Funding Hawaiian Electric Company and the Kauai Electric Division of Citizens Utilities Co.

Schedule As Soon As Possible

Proposals for Hawaii's Petroleum Industry

PETROLEUM PROPOSAL I

Identify Generator Backup Requirements for the Petroleum Industry

Description

In the absence of commercial power, a large number of portable emergency generators will be needed to maintain normal operation of the entire petroleum industry. The number of generators needed following a loss of power is almost certainly going to exceed the number available. In conjunction with state and local emergency authorities, the petroleum industry should reserve a sufficient number of portable generators to permit an uninterrupted flow of petroleum products for civilian and emergency use. Unless these generators are reserved, fuel will not be available for cars, trucks, buses, and the aviation and shipping industries.

It is proposed that the petroleum industry on each of the Hawaiian Islands conduct a survey to determine the quantity, voltage and power levels, and phase requirements of portable emergency generators for critical locations necessary for the continued distribution of petroleum products.

The survey should also identify those retail gasoline service stations with existing emergency generator disconnect switches and hookups to separate them from the commercial power grid when the emergency generator is in use. The disconnect switches are required to prevent the commercial power grid from being energized when the generator is running, thus preventing utility repairmen from being accidentally electrocuted. Stations with emergency hookups and disconnect switches should receive priority consideration for civil defense portable generators.

The results of the survey should be forwarded to the Hawaii State Civil Defense for use during an emergency.

Background

The reliable operation of all aspects of the petroleum industry on the Hawaiian Islands is dependent upon the availability of electric power. Without electric power, loading and unloading of crude oil and products from tankers and barges, movement of product through pipelines, and pumping of product at commercial loading racks and retail gasoline stations would cease. The BHP and Chevron refineries on Oahu are essentially self-sufficient in generation of electric power. However, the operations downstream of the refinery, including pipelines, terminals, and retail outlets are dependent upon commercial electric power.

It is recommended. . .

that this proposal be implemented. The study should be conducted by the petroleum industry on each of the islands with overall guidance and data format assistance from appropriate State Authorities.

Lead Agencies Department of Business, Economic Development and Tourism (DBEDT), Energy Division

Funding None by the State of Hawaii. Individual refineries and service stations could incur a one-time cost for surveying their facilities to determine the power, voltage, and technical requirements of portable emergency generators needed to continue operations.

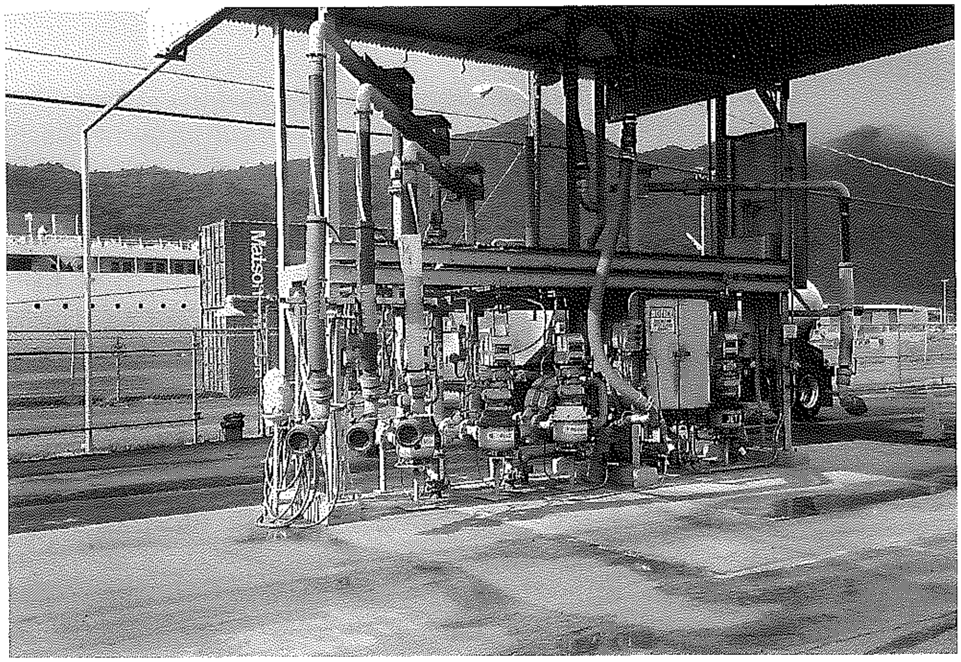
Schedule A request to individual refineries and service stations by DBEDT for estimates of their power requirements should be made as soon as possible, and it would be in the interest of individual refineries and service stations to respond as soon as possible.

PETROLEUM PROPOSAL II

Modify Tank Trucks and Loading Terminals

Description Convert all tank trucks to both top and bottom loading capability. Eventually, convert all bulk petroleum distribution terminals to bottom loading racks.

Background Many bulk terminals are still using older top loading racks (pipes which fill tank trucks), particularly on the Neighbor Islands. The newer bottom loading racks are generally safer and more environmentally acceptable (assuming vapor recovery is employed). Most tank trucks are configured for either top or bottom loading but not both. A few top loading trucks have been modified to accommodate bottom loading. As terminals are modernized, they are generally adapted to bottom loading racks. Converting all tank trucks to both top and bottom loading would greatly increase the supply/distribution flexibility of petroleum products during an emergency where some bulk terminals and/or tank trucks were rendered unusable.



An example of a bottom loading racks.

The costs to adapt a tank truck to bottom loading can range up to $10,000 per vehicle. The cost of modernizing a bulk terminal is several million dollars or more depending on how extensive the upgrades are. For example, it is estimated that one terminal operator recently spent six million dollars for a state of the art renovation which included new concrete berms, bottom loading racks, vapor recovery facilities, spill recovery ponds with plastic liners, perimeter foam fire fighting equipment, anchored tanks, and other enhancements.

Capital investments of this magnitude can not be justified solely on the basis of hazard mitigation, given the projected frequency of events. However, when other factors such as reduction in liability and fire insurance premiums, adherence to new environmental standards, and reinforcing a public image of responsibility, are considered, the costs may be justified in the long term.

This proposal is not recommended. . .

on a cost/benefit basis. However, voluntary conversion of tank trucks to both top and bottom loading would increase the reliability of fuel loading following an emergency or natural disaster.

Lead Agencies Hawaiian Fuel Terminal Operators

Funding By Petroleum Terminal Operators, at their discretion when funds become available

Schedule To be determine by the individual Petroleum Terminal Operators

PETROLEUM PROPOSAL III

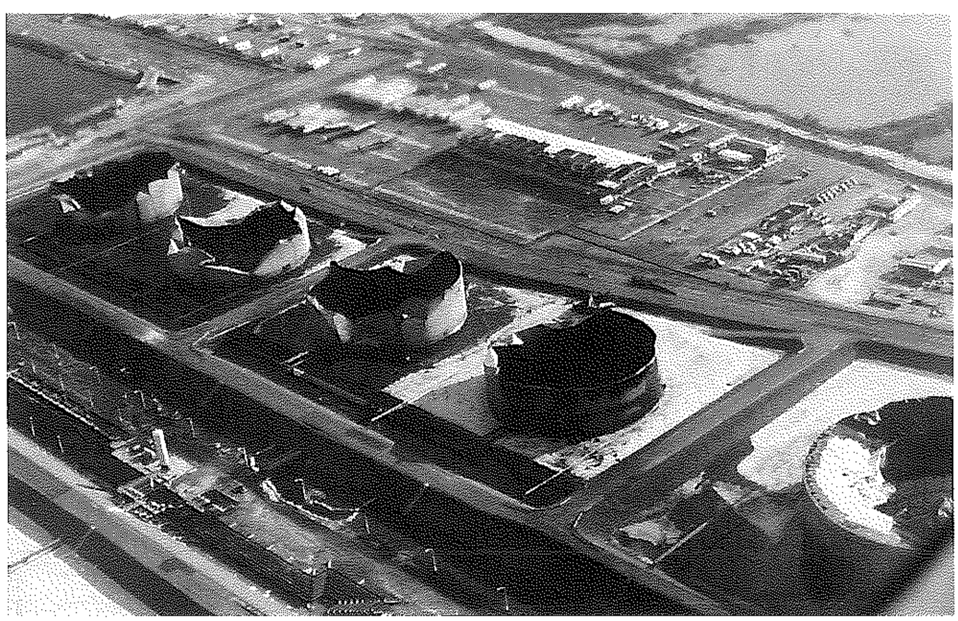
Protection of Petroleum Storage Tanks

Description

Consider filling larger and newer storage tanks, which are empty, with water when sufficient crude oil/product is not available and tanks appear to be in the direct path of an approaching Catastrophic Class 5 hurricane. This practice would help protect tanks from storm surge which in some areas could result in tanks floating off their bases (those which are not bolted to concrete bases) and from high winds, which in other island locations have resulted in empty tanks being totally destroyed due to implosion. **Note: Tank bottoms and walls of older tanks may not be capable of accommodating the additional weight of water. Older tanks should not be considered for water fill unless evaluation of engineering/design plans and as-built schematics show that they can withstand the additional weight of water.**

Background

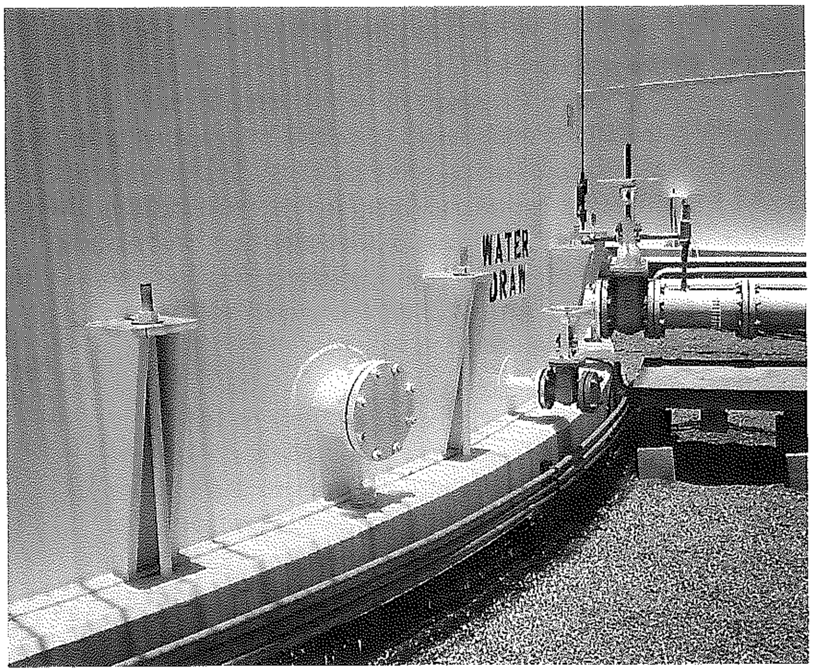
During Hurricane Hugo in 1989, approximately a dozen tanks including five large petroleum storage tanks were completely destroyed by high winds on the U.S. Virgin Islands. The petroleum tanks took 18 months to rebuild. While the time required to build new tanks is influenced by many factors, the average time for constructing a new tank currently ranges from approximately eight months for a small tank (25,000 barrels or less) up to 18 months for some larger tanks (200,000 barrels and up). This estimate assumes no abnormal delay in obtaining the necessary building and environmental permits.



Five large petroleum tanks destroyed by high winds on the U.S. Virgin Islands.

Damaged tanks are expensive to rebuild. The current cost estimate for rebuilding a tank on Hawaii (costs are approximately 15% percent higher than the on mainland due to increased labor and shipping costs) ranges from $10 to $15 per barrel of capacity, depending on the size of the tank and the type of roof configuration employed. This estimate includes building the foundation and painting the tank, but does not include the cost of dismantling or removing an old tank.

An example of a new anchored oil storage tank at a petroleum distribution terminal.



The loss of several tanks on the Island of Oahu may not seriously impact the overall distribution network. However, the loss of several larger tanks on one of the Neighbor Islands, with a much smaller infrastructure, could significantly affect product availability and have a profound economic impact on the terminal operator and the local economy.

It is essential to protect existing tanks in the direct path of an approaching Catastrophic Class 5 hurricane (winds 156 mph or greater). Consideration should be given to adopting a water fill policy when insufficient product or crude oil is available for tank fill. This should be followed up with water treatment and disposal procedures.

In most instances, terminals on the Neighbor Islands do not have oil/water separators for treating small quantities of rain water runoff. Treating large quantities of tank ballast water following a Class 5 hurricane would present a major dilemma: How would large quantities of contaminated water be decontaminated and disposed of in an economically and environmentally acceptable manner?

On Oahu there are refineries and other facilities with bio-remediation water treatment capability. These facilities should be allowed to reprocess water contaminated with oil from non-affiliated terminals during emergencies. Processing arrangements, water quality standards, and a pre-established fee structure should be formulated in advance. This procedure would allow terminal operators with low or empty tanks, which are considered critical to their operation, to consider using water as tank ballast to protect against flooding and wind damage. It is recognized that processing contaminated water is very expensive and would only be used as a last resort. These emergency procedures should only be considered if direct contact by a Catastrophic Class 5 hurricane appear imminent.

It is recommended. . .

that this proposal be studied in greater detail to evaluate the feasibility of reprocessing tankfill water on Oahu. In addition, this detailed evaluation should determine if the appropriate authorities would approve the process, if it could be implemented without violating state and federal effluent regulations, and if enough fresh water would be available for tankfill without adversely impacting the overall water supply and the emergency residential water fill program. If water supply and reprocessing capacity are found to be inadequate, the feasibility of combining stocks and balancing tank inventories to minimize damage should be examined as an alternative.

Lead Agencies Hawaii State Civil Defense and local and federal environmental protection authorities

Funding To be determined by the lead agencies

Schedule To be determined by the lead agencies

PETROLEUM PROPOSAL IV

Decentralize Cooling Towers at Refineries

Description Refiners on Oahu should consider replacing large centralized wooden cooling towers with smaller decentralized fin/fan cooling units to reduce the potential for hurricane-related wind damage and associated operational downtime.

Background Damaging Hurricanes have a recurrence interval of approximately 50 years on Oahu. Nevertheless, a major hurricane hitting Oahu directly could have a significant impact on the primary Hawaiian production and distribution point for essential commodities and services such as fuel, food, communications, etc. Other refiners have opted for smaller, decentralized cooling units to reduce overall vulnerability even though overall efficiency may be somewhat reduced.

The frequency of hurricanes on Oahu does not justify an immediate retrofit on a cost/benefit basis. However, as existing equipment is replaced, future cooling unit decentralization may be justified due to enhanced system reliability.

It is recommended. . .

that this option be studied in greater detail. If feasible, develop plans for gradual implementation as new equipment is required. In the interim, develop contingency plans for responding to the loss of the central cooling tower using alternatives such as once through-cooling using subsurface aquifers.

Lead Agencies Oahu refiners

Funding To be determined by the Oahu refiners

Schedule To be determined by the Oahu refiners

PETROLEUM PROPOSAL V

Encourage Continued State/Industry Planning and Coordination

Description The State of Hawaii should provide guidance to assist petroleum terminal operators in their long range planning. This would effectively encourage capital investment in modern terminal facilities and foster diversification of petroleum suppliers on the islands. State involvement and guidance would aid in maintaining up-to-date and comprehensive emergency planning by individual companies compatible with the overall State Emergency Plan.

Background Many terminal operators with facilities currently located in the Honolulu Harbor area may be displaced by the Honolulu Waterfront Redevelopment Plan. This uncertainty discourages capital investment and may, in some cases, hamper effective emergency response planning, appropriate spill response and, environmental measures. Consideration should be given to setting aside new areas for petroleum terminals with dedicated piers for terminals on Oahu. Where similar relocations are likely on the Neighbor Islands as a result of state redevelopment plans, new terminal areas should also be set aside.

The Oil Pollution Act of 1990 virtually mandates certain major capital improvements. Without renewal of long-term leases, terminal operators will not have the time necessary to recover their capital investments and such investments are very unlikely to be made. Long-term leases are crucial to maintain diversification of petroleum supply and sustain terminal redundancy which facilitates adequate supply during emergencies.

It is recommended...
that this proposal be studied in greater detail.

Lead Agencies Governor's Advisory Committee

Funding To be determined by the Governor's Advisory Committee

Schedule To be determined by the Governor's Advisory Committee

PETROLEUM PROPOSAL VI

Improve Neighbor Islands Emergency Communications Capability

Description In order to improve dissemination of emergency preparedness alerts/ warnings and coordinate emergency response, the communications capability needs to be upgraded on some of the Neighbor Islands. Consideration should be given to acquiring more cellular phones and marine radios for energy suppliers, where appropriate, and supplying each island with a portable satellite communication backup system. In addition, both state and local officials should familiarize themselves with the new Government Emergency Telecommunications System (GETS) so they know how to gain access to the telephone network during an emergency.

Background During discussions with petroleum suppliers on the Neighbor Islands, it appeared that many individuals felt that rapid and reliable communication immediately preceding or during an emergency was an area of great concern. During an emergency in which the Clean Island Council is activated, sufficient on-site communication capability should be available on the affected Neighbor Island.

Some individuals suggested that more cellular phones were needed to coordinate deliveries with customers, coordinate resupply logistics with headquarters, and, in general, apprise government officials of their supply status.

It is recommended. . .

that this proposal be studied in greater detail. It is possible that a portion of this proposal could be justified under the "Lifeline" section of this study.

Other individuals expressed an interest in gaining access to marine single side band radios to communicate with barge operators and the Coast Guard during resupply or spill response efforts on a designated common frequency.

In general, it was also felt that each of the Neighbor Islands should have access to a battery-powered satellite communication backup unit, similar to the units on the Islands of Hawaii and Molokai, at a cost of approximately $25,000 per unit.

Lead Agencies Hawaii State Civil Defense

Funding To be determined by the lead agencies

Schedule To be determined by the lead agencies

PETROLEUM PROPOSAL VII

Promote Major Spill Response Exercises

Description The industry should continue frequent on-the-water exercises with ***all*** affected parties participating or, as appropriate, observing. Exercises should include refiners, terminal operators, the Marine Spill Response Corporation (MSRC), the Clean Islands Council, the Pacific Environmental Corporation, (PENCO), the U.S. Coast Guard, etc., in order to test the ability to coordinate and communicate. Response issues such as decanting, water disposal, use of dispersants, and in-situ burning should be evaluated and discussed with appropriate local, state and federal authorities and, if possible, pre-approved in advance of an emergency.

Background Oil spills can have a profound effect on access to ports, electric power generation, and beach areas frequented by tourists.

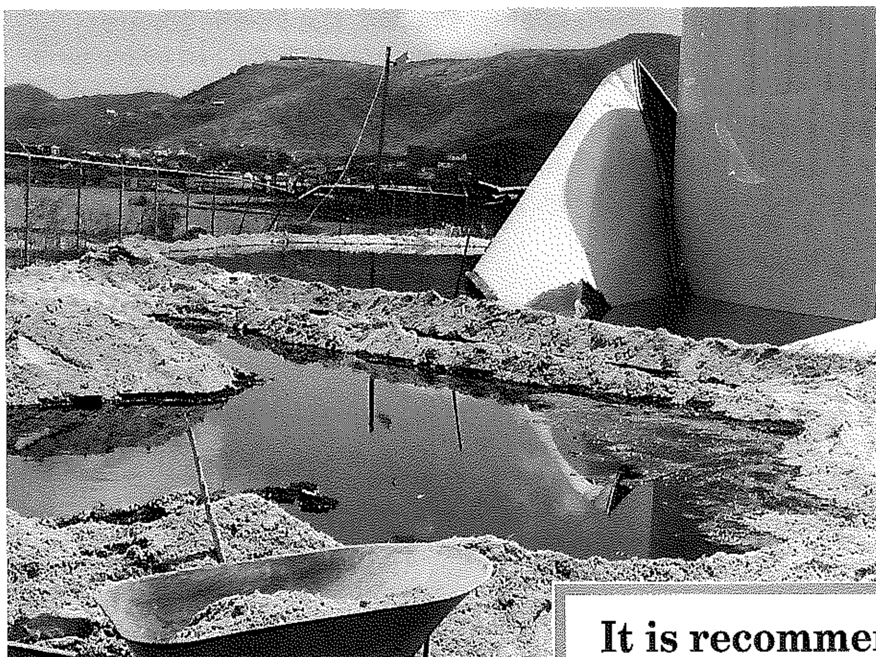
During the EXXON VALDEZ spill in Prince William Sound, Alaska, oil shipments from the Port of Valdez were reduced by 50 percent for 8 days because of oil slicks in the tanker channels. In the case of the Hawaiian Islands, a major spill could affect both incoming crude oil shipments as well as exports of refined product to Neighbor Islands.

During Hurricane Hugo, oil spills also threatened water intakes for electric power generation stations in the Caribbean, which could have forced shutdowns if these plants had not been down for other reasons.

Oil Spill Recovery Operations off of St. Croix after Hurricane Hugo.

The 1993 oil spill in San Juan, Puerto Rico contaminated prime resort beachfront, having a significant adverse impact on tourism. Resort areas, which are very dependent on tourism, can be greatly affected by spills and therefore need special attention in planning and coordination of rapid response measures.

The refiners in Hawaii, BHP and Chevron, as well as major terminal operators, appear to be proactive in spill planning and coordination. In 1994, several major spill response exercises were conducted including a Command Post Exercise in April and an on-the-water National Pollution Response Exercise Program (NPREP) Exercise in June. To date, no surprise Readiness Evaluation Exercise (REE) has been held by MSRC on the West Coast or Hawaii. The REE's, which are planned a year in advance and kept confidential, are held once per year. In November 1993, the surprise REE was conducted off the coast of New Jersey. In October 1994, the annual REE was held off the coast of Texas.



An Oil Spill on St. Croix after Hurricane Hugo.

It is recommended...

that this proposal be studied in greater detail and that clients of the MSRC investigate the possibility of requesting that an REE be held in Hawaii.

Lead Agencies U.S. Coast Guard and the appropriate State of Hawaii Officials

Funding To be determined by the lead agencies

Schedule To be determined by the lead agencies

PETROLEUM PROPOSAL VIII

Enhance Emergency Crude Oil Resupply Compatibility or Maintain a Pipeline Interconnect Between Refineries

Description

Offshore moorings at adjacent refineries on Oahu should be compatible, so that in the event of one mooring being rendered inoperable, tankers would have the capability to offload at the other location.

Consideration should be given to building a standby crude oil pipeline interconnection onshore between the Chevron and BHP refineries for added emergency flexibility. It is also important to retain unused product pipelines connected to offshore moorings which could be used as backup lines in the event of an emergency.

Background

There are two offshore moorings for unloading crude oil onto Oahu. A single point mooring (SPM) for the BHP refinery and a nearby seven point mooring for the Chevron refinery. Approximately 50 percent of crude oil tankers have the capability to use both the SPM and seven point moorings. The oil spill liability issue may hinder any cooperative effort to share offshore moorings, even during an emergency. However, an onshore pipeline interconnection between the adjacent refineries could facilitate crude oil resupply during an emergency affecting either offshore mooring and obviate the need for interchangeable offshore mooring capability.

It is recommended...

that this proposal be studied in greater detail.

Lead Agencies U.S. Coast Guard and BHP and Chevron

Funding To be determined by the lead agencies

Schedule To be determined by the lead agencies

PETROLEUM PROPOSAL IX

Promote Use of Kawaihae Harbor on the West Coast of the Island of Hawaii

Description The State should encourage an active port/terminal facility for offloading and storing petroleum products in the area of Kawaihae Harbor on the Kona side of Hawaii, particularly since this is the fastest growing area on the island.

Background Although some refined product is being imported at Kawaihae Harbor, many existing facilities are being supplied by truck from terminals at Hilo on the other side of the island. Hilo terminals are supplied by Chevron and BHP barges from Oahu.

Approximately 10 tank trucks per day are currently making the 160 mile round trip from Hilo to the west side of the island. The number of tank trucks making this round-trip is expected to increase as the population in the Kona area expands. This long supply line could be disrupted during an emergency. Only two major roads are available for tank truck transportation which are susceptible to fire and lava flows. Resupplying terminals at Kawaihae Harbor via water would also promote highway safety by reducing the number of tank trucks carrying hazardous cargoes on the island.

Increased use of the Keahole Airport at Kona has prompted discussion of constructing a jet fuel pipeline between Kawaihae Harbor and Keahole Airport. Based on meetings with industry members, it appears doubtful that a proposed jet fuel pipeline will be constructed in the near term due to the high cost of construction through lava fields.

It is recommended...
that this proposal be studied in greater detail.

Lead Agencies Department of Business Economic Development & Tourism (DBEDT), Energy Division

Funding To be determined by the lead agencies

Schedule To be determined by the lead agencies

PETROLEUM PROPOSAL X

Keep Petroleum Terminals Open 24 Hours Per Day Following a Major Emergency

Description Arrangements should be made in advance to keep oil terminals open on a 24-hour per day basis during the initial emergency response period (5-7 days) following a major disaster. This would require allocating at least two people to operate the terminal during the initial recovery period.

Background Most disaster relief efforts require around-the-clock access to transportation fuels, particularly aviation fuels. Following Hurricane Iniki, terminals on Kauai did not remain open on a 24-hour per day basis. In some cases, a single individual operated an entire terminal for up to 15 hours per day, after which the terminal was closed. It was felt that access to aviation fuels was really needed on an around-the-clock basis during the initial phase of a major emergency response effort such as Hurricane Iniki. In addition, Civil Defense announcements regarding the fuel availability situation would be helpful in avoiding panic filling which could drain supply systems.

It is recommended...

that the Governor's Energy Emergency Preparedness Advisory Committee coordinate with terminal operators to design and implement a plan to keep terminals open immediately following an emergency requiring access to transportation fuels.

Lead Agencies Governor's Energy Emergency Preparedness Advisory Committee and the Hawaiian Fuel Terminal Operators

Funding To be determined by voluntary agreement between the Governor's Energy Emergency Preparedness Advisory Committee and the Hawaiian Fuel Terminal Operators

Schedule To be determine by agreement

PETROLEUM PROPOSAL XI

Promote Industry Mutual Assistance Pacts

Description Encourage oil terminal operators to formalize mutual assistance pacts to respond to emergencies (spills, fires, etc.) on a regional basis.

Background Although many examples of informal cooperation between operators of oil terminals on Hawaii were cited, formal mutual assistance pacts (other than Clean Islands Council) could offer added benefits. For example, formal mutual assistance pacts have been effectively used in other areas (e.g., Houston Ship Channel) to coordinate purchases of expensive equipment, which when used in a coordinated fashion, significantly improves local emergency response capability in a cost effective manner.

Since competition between oil companies may occasionally hinder pre-emergency planning as well as coordinated responses during an emergency, State officials could serve as the catalyst by asking industry to work together in setting up regional mutual assistance agreements, including compensation provisions where appropriate.

It is recommended...

that the Governor's Energy Emergency Preparedness Advisory Committee act as a focal point in promoting the increased use of mutual assistance pacts in areas of concentrated infrastructure.

Lead Agencies Governor's EEP Advisory Committee and the Hawaiian Fuel Terminal Operators

Funding To be determined by voluntary agreement between the Governor's EEP Advisory Committee and the Hawaiian Fuel Terminal Operators

Schedule To be determine by agreement

PETROLEUM PROPOSAL XII

Establish a Separate Federal Emergency Management Agency – Regional Interagency Steering Committee (FEMA-RISC) Subregion for Hawaii

Description Institute a separate FEMA-RISC subregion (Region IX-Hawaii) in order to promote coordination on emergency preparedness issues between Hawaii state and local officials and federal emergency respondents (Emergency Support Function Agencies). RISC meetings could be held at various locations in Hawaii several times a year with a major state/federal emergency preparedness exercise held every other year.

Background Alaska, which is isolated from the other states, hosts their own separate subregional RISC meetings (Region X - Alaska) to ensure coordination between state and local officials and federal emergency respondents. These meetings also serve as a forum to discuss issues and problems which are more unique to Alaska. Alaska and FEMA also normally host a major Response Exercise every other year in Alaska.

Hawaii, since it is also isolated from the mainland, may want to consider adopting this approach by hosting occasional meetings as Region IX - Hawaii.

It is recommended...
that this proposal be studied in greater detail.

Lead Agencies The Federal Emergency Management Agency and the Hawaiian Civil Defense Authorities

Funding To be determined by the lead agencies

Schedule To be determined by the lead agencies

Proposals for Hawaii's Gas Industry

GAS PROPOSAL I

Protect LPG Barges Used in Inter-Island Service

Description During periods of increased risk (hurricanes, flooding, tsunamis), precautions should be taken to shelter LPG barges. This could be accomplished by making arrangements in advance to dock the barges in safe harbors (leeward side of islands or harbor not exposed to tsunami) or to take them to sea where the tow can be more carefully controlled.

Background Because most of Hawaii's inter-island commerce moves by barge, there are few "spare" barges in the distribution system. This is especially true of the LPG barges, where the LPG-dedicated barges are in constant service from Oahu to the other islands. There is no "spare" LPG barge, and it could take up to a year to build a replacement barge.

It is recommended...
that this proposal be studied in greater detail.

Lead Agencies LPG Industry

Funding To be determined by LPG Industry

Schedule To be determined by LPG Industry

GAS PROPOSAL II

Install Shutoff Devices on All LPG Tanks in Inundation Areas

Description All LPG (also called propane) tanks and cylinders located in tsunami or hurricane inundation areas (as defined by U.S. Army Corp of Engineers maps) should be equipped with breakaway shutoff devices to prevent gas leaks when tanks are separated from their foundations.

Background While most of the larger American Society of Mechanical Engineers (ASME) rated LPG tanks currently have automatic shutoff devices, some large tanks and most smaller tanks and cylinders (400 pounds/ 100 gallons and below) do not have shutoff devices. During the severe Midwest flooding in the summer of 1993, a large LPG tank broke loose, leaking its contents as it floated down the Mississippi River. This incident dramatically showed how dangerous leaking LPG tanks can be to adjacent population centers.

It is recommended. . .

that all LPG tanks located in tsunami or hurricane inundation areas be equipped with automatic shutoff devices.

Lead Agencies County Fire Departments and Hawaii State and County Civil Defense

Funding To be determined by the lead agencies

Schedule To be determined by the lead agencies

GAS PROPOSAL III

Provide Maps Showing Locations of Key Shutoff Valves for Underground Gas Utility Systems (Oahu, Hawaii, Maui) to Appropriate Fire Department Officials

Description Where underground LPG or synthetic gas distribution systems exist (Oahu, Hawaii, and Maui), the gas distribution companies should provide the county and local Fire Departments with maps showing the locations of pipelines and shutoff valves.

Background Underground residential and commercial gas utility systems are in use in densely populated areas on the Islands of Oahu, Maui and Hawaii. During gas utility emergencies, employees of the respective gas companies would normally respond and take the appropriate corrective action.

Given the confusion and lack of mobility that often accompanies emergencies such as major hurricanes, tsunamis, earthquakes, and volcanic eruptions, it may be beneficial to give a set of gas utility system maps to fire department officials. These maps would be used for emergency shutoff purposes only in the event that gas company representatives were unable to respond in a timely manner. For example, over 150 fires were caused by severed gas lines during the 1995 earthquake in Kobe, Japan. In some instances, it took several days before the gas in the severed lines was turned off and the fires were extinguished.

It is recommended...
that this proposal be studied in greater detail.

Lead Agencies Department of Business, Economic Development, and Tourism (DBEDT), Energy Division

Funding To be determined by the lead agencies

Schedule To be determined by the lead agencies

GAS PROPOSAL IV

Install Automatic Gas Shutoff Valves on Mainline Gas Pipelines in Urban Areas Exposed to Earthquake Risk

Description

On those islands exposed to earthquake risk, consideration should be given to installing automatic or remote-operated valves on mainline gas pipelines in densely populated areas. These valves would provide for the rapid shutdown of a pipeline system and greatly reduce the risk of a major fire in the event of a pipeline rupture. In those areas where automatic or motor operated mainline shutoff valves currently exist, they should be examined periodically to ensure that they still function properly.

Background

Recent experiences during the earthquake in Kobe, Japan and the Texas Eastern Pipeline rupture in New Jersey graphically demonstrate the need for mainline shutoff valves that automatically close during large pressure drops or motor operated valves that can be remotely closed during an emergency.

During the Kobe Earthquake severed gas lines continued to burn for several days greatly increasing the fire damage associated with the earthquake.

During the Texas Eastern Pipeline rupture in New Jersey, it took nearly two and one half hours (750 turns on each of three valves) to manually shutoff the gas flowing to the ruptured segment. The National Transportation Safety Board (NTSB) suggested that much of the $25 million in property damage could have been avoided if the gas had been turned off sooner.

The island with the greatest risk is Hawaii, with an assumed damaging earthquake recurrence interval of 25 years. Although Maui and Oahu have longer expected earthquake intervals (50 years), consideration of mainline automatic shutoff valves may also be advisable due to the density of population in the Lahaina and Honolulu areas.

It is recommended...

that this proposal be studied in greater detail. If feasible, develop plans for gradual implementation in those areas with the highest risk.

Lead Agencies Gas Utility Companies

Funding Not Applicable

Schedule Not Applicable

Proposals for Hawaii's Lifeline Industry

LIFELINE PROPOSAL I

Provide Priority Restoration of Commercial Electric Power to Lifeline Entities Following Supply Disruptions

Description

Any of the natural disasters addressed by this hazard mitigation study (hurricanes, extreme winds, earthquakes, and volcanic activity) are capable of causing widespread electrical outages on Hawaii. This proposal discusses priority restoration of commercial electric power to the lifeline entities on Hawaii. For the purposes of this study and this proposal, lifeline entities include: police, fire, and medical services; telecommunications; suppliers of potable water; suppliers of food; and waste water treatment facilities.

Background

The normal operation of electric utilities requires that the amounts of power generated and consumed by loads and losses be kept in very close balance on a continuous basis. Failure to maintain this balance will cause a system outage. The time required to restore electrical service following an outage is in large part due to the constant need to maintain this electrical balance while restoring service. A utility will monitor the status of its electrical systems and increase generation while connecting additional loads.

The extent of the damage to an electrical system following natural disasters is the primary determinant of the length of the time required to restore electric service. Following an outage, a utility initially starts its undamaged generation and powers its own internal system loads, controls, and operating equipment. Utilities then start the restoration process by attempting to provide power to the greatest number of customers in the shortest possible time. In the initial phase of the restoration process, a utility will typically send out crews to replace fuses and reclose circuit breakers, providing service to customers connected to undamaged power lines. Because functional generation and transmission are both required to deliver power to distribution lines, repairs to generation and transmission are normally made simultaneously. Repairs to distribution lines may also be made simultaneously if the situation and resources permit. However, distribution is normally returned to service following repair of the transmission system.

Electric utilities have little flexibility in their operations while they are repairing generation and transmission and restarting generating units. During this period it is not practicable to prioritize the restoration process. This generation and transmission recovery period is analogous to a person regaining their feet. A person lacks maneuverability until they are on their feet. However, once substantial generation and transmission repairs have been made and repair efforts are shifting to the distribution system it becomes possible to give priority to restoring selected loads.

Selection of which loads will receive priority during the distribution repair phase of the restoration process is essentially a political decision rather than a technical decision. Decisions concerning electric power restoration priorities are part of the Governor of Hawaii's emergency authorities. However, normally this authority is delegated to the state Public Utilities Commission.

The state of Hawaii should consider formalizing the procedure to provide critical lifeline entities with priority restoration of their electric power, consistent with the restoration of overall electrical service.

It is recommended. . .
that this proposal be implemented to the extent practical.

Lead Agencies Department of Business, Economic Development and Tourism (DBEDT) Energy Division; Hawaii Public Utilities Commission

Funding None Required

Schedule As Soon As Possible

LIFELINE PROPOSAL II

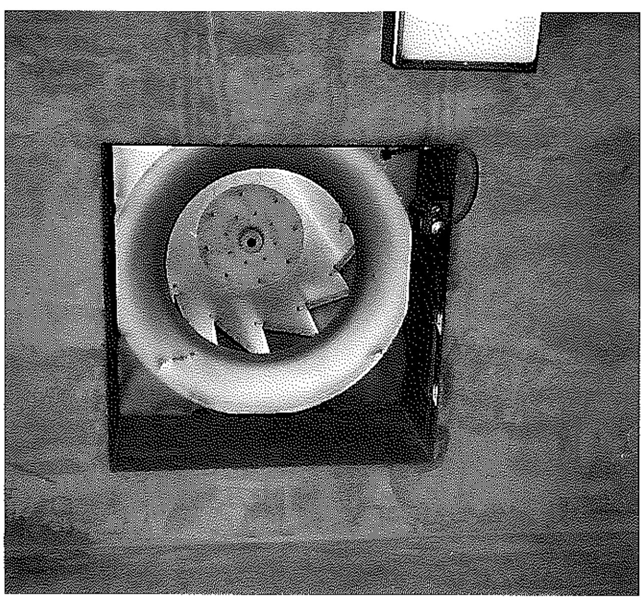
Recommendations to Increase the Reliability of Emergency Generators

Description Provide voluntary operating and testing guidelines to critical lifeline facilities with backup emergency generation.

Background Extensive interviews with operators of backup emergency generators at lifeline facilities indicated that reliability problems do exist and that more stringent and uniform testing guidelines should be considered. Specific recommendations are as follows:

II-A Emergency Generators Should Be Started at Least Twice Per Month and Run Under Full Load for a Minimum of Four Hours During Each Test Period

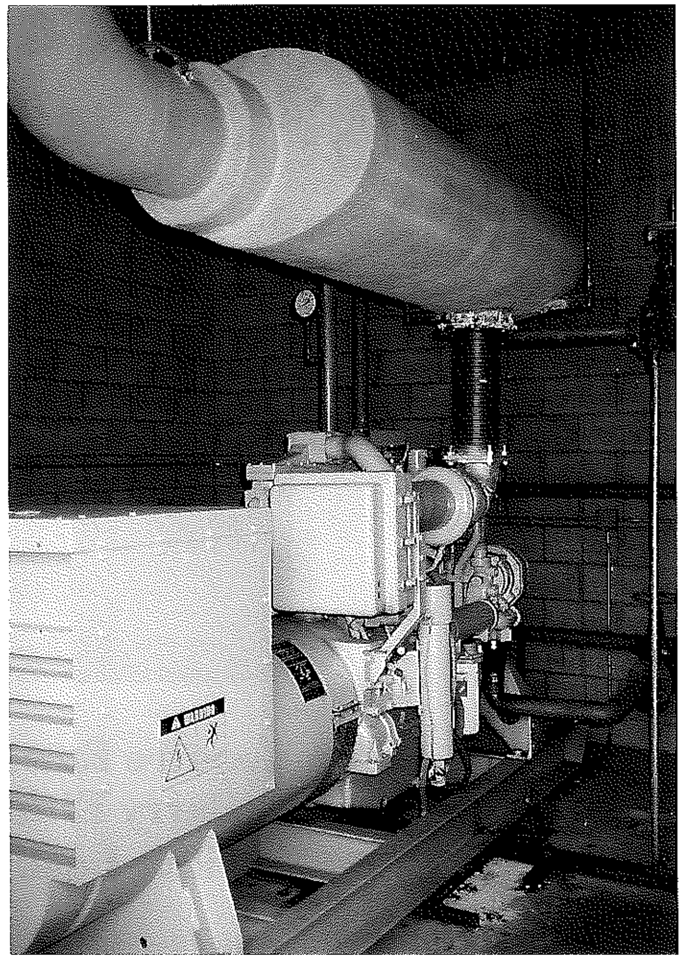
Background All emergency backup generators at lifeline facilities should be started and run, twice per month at a minimum, to detect potential reliability problems such as faulty batteries (starting problems), overheating, and fuel degradation. Starting and running the generators under load for a minimum of four hours can detect many problems which could affect long term reliability under a variety of conditions. One major problem encountered was generator overheating. In many cases, ventilation doors needed to be opened manually, even if the generators started automatically, upon loss of commercial electric power. If the doors were not opened in a relatively short period of time, the generator(s) would simply overheat and shutoff. Actions which can be taken to prevent overheating include installation of vent holes with thermostatically controlled fans, insulating the exhaust pipe and muffler, and placing the radiator outside of the generator room.



An example of a thermostatically controlled ventilator fan in a closed emergency generator room.

Another problem encountered with the operation of emergency generators is contamination and/or degradation of stored fuel. Running the generators 4 hours at a time at least twice per month should turn over fuel inventories frequently enough to avoid fuel problems.

An example of a insulated exhaust system to reduce heat buidup in a closed emergency generator room.

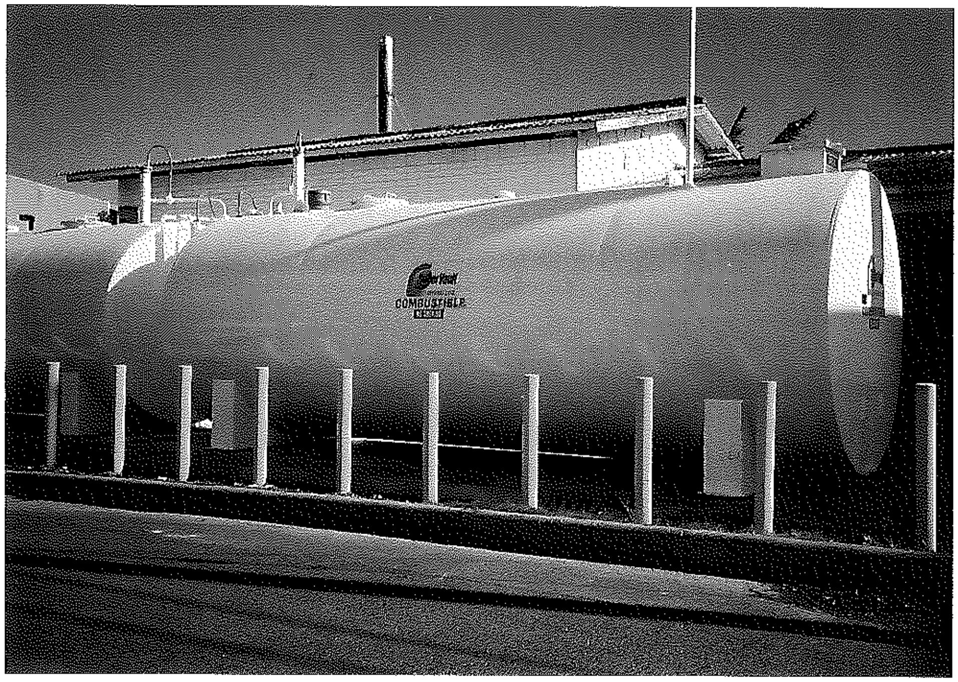


II-B A Minimum of 5-Days' Supply of Fuel for Emergency Generators at Lifeline Facilities Should Be on Hand At All Times

Background

Following a disaster which can not be predicted (such as an earthquake), it is assumed that 5 days will be required before significant amounts of federal aid arrives. Following a disaster which can be predicted (such as a hurricane) and allows prepositioning of resources, significant amounts of federal resources will normally arrive within 3 days. A 5-day supply of fuel for backup emergency generators at lifeline facilities is recommended to prepare for the worst case, an unexpected disaster.

During Hurricane Iniki, some operators of critical lifeline services on Kauai encountered significant delays in obtaining fuel resupply from wholesale distributors. As a consequence, one medical facility has installed two large (6,000 gallons each) concrete lined, above ground storage tanks to extend their emergency generator fuel supply.



Large Above-Ground Petroleum Storage Tank

II-C Require Emergency Generators to Be Sized to Carry Either All Critical Loads or the Full Facility Load

It is preferable that lifeline facilities identify critical loads and size emergency generators accordingly. However, DOE experience shows that defining and choosing critical circuits has proven to be difficult or impossible. In those cases, generators should be sized to accommodate the entire facility. Longer duration testing (II-A) helps to determine if the capacity of the emergency generator(s) is sufficient for existing loads or if generator size needs to be increased or a load shedding plan initiated.

It is recommended...

that the above procedural guidelines, (Proposal II A, B, and C) pertaining to emergency power generators, be adopted by the Department of Business, Economic Development and Tourism, Energy Division and distributed to operators of critical lifeline industries.

Lead Agencies Department of Business, Economic Development and Tourism (DBEDT), Energy Division

Funding None by the State of Hawaii although individual lifeline entities could incur increased costs

Schedule The procedural guidelines pertaining to emergency power generators should be provided to individual lifeline entities as soon as possible.

LIFELINE PROPOSAL III

Lifeline Entities Without Backup Generators Should Provide the Hawaii State Civil Defense with Information Concerning Their Emergency Power Needs

Background Some critical lifeline functions do not currently have backup emergency generators on site. For those lifeline sites without emergency generators, power requirements and approximate daily fuel usage should be determined for both the critical circuits load only and the full facility load. In addition, the voltage, phase, and electrical connector requirements should be identified to facilitate connection to portable generators supplied by either local government, the State of Hawaii, or the Federal Government following an emergency.

It is recommended...

that lifeline entities without emergency generators provide the Department of Business, Economic Development and Tourism (DBEDT) Energy Division with details of their power requirements to expedite generator dissemination during an emergency.

Lead Agencies The Department of Business, Economic Development (DBEDT) Energy Division and the individual lifeline entities

Funding None by the State of Hawaii. Individual lifeline entities could incur a one time cost for surveying the power requirements of their critical lifeline functions or their overall facility power requirements.

Schedule A request to individual lifeline entities by the Department of Business, Economic Development and Tourism (DBEDT) Energy Division should be made as soon as possible, and it would be in the interest of individual lifeline entities to respond as soon as possible.

LIFELINE PROPOSAL IV

Provide 7-Day Minimum Vehicle Fuel Guideline for Critical Lifeline Services

Description Critical lifeline locations should have, or have access to, a minimum of 7 days of normal fuel supply for their vehicles.

Background Although federal aid normally begins arriving 3-5 days following a disaster, a 7-day fuel supply is recommended for emergency vehicles because of above normal fuel consumption levels following a disaster and unpredictable fuel resupply deliveries. For example, during Hurricane Iniki on Kauai, some operators of critical lifeline services encountered fuel resupply problems. Distributors were inundated by individuals purchasing small quantities of fuel (since the retail gasoline stations were closed) which prevented them from making their normal commercial account deliveries on a timely basis.

Lifeline services (without on site fuel storage) that normally purchase fuel from wholesale distributors or retail gasoline stations, should ascertain if those gas stations either have backup generators or at least are equipped with electric disconnect switches and emergency hookups to accommodate portable electric generators.

It is recommended...

that minimum lifeline entity vehicle fuel supply guidelines be adopted by the Department of Business, Economic Development and Tourism (DBEDT) Energy Division and disseminated to critical lifeline users.

Lead Agencies The Department of Business, Economic Development and Tourism (DBEDT) Energy Division

Funding None by the State of Hawaii

Individual lifeline entities may, if they chose to expand vehicular fuel storage incur a one time cost for expanding fuel storage capacity and continuing holding costs for increased fuel storage.

Individual commercial gasoline stations which choose to install either backup generators or electrical switches and connectors would have to pay for these capital improvements.

Schedule Guidelines concerning vehicular fuel storage recommendations should be provided to appropriate lifeline entities as soon as possible. Lists of commercial gasoline stations equipped with, or currently able to be connected to an emergency generator should also be compiled as soon as possible.

APPENDIX A

Data Used to Determine Time Periods of Potentially Damaging Natural Hazards

EARTHQUAKES:

Reference: Earthquake Database, 1994
National Geophysical Data Center
National Oceanic and Atmospheric Administration
325 Broadway
Boulder CO 80303

Figures 1, 2, and 3 show the historical earthquake data for the period of 1834 to 1994.

HURRICANES:

Reference: Global Tropical and Extratropical Cyclone Climate Atlas

Version 1 (CD), March 1994
National Climatic Data Center
Federal Building
Asheville, NC 28801-2733

Ocean Basin Selection:
EAST N PAC

Sequential Date Select Option:
Begin Jan/1950
End Mar/1994

All-of-map Area Select Option:
LAT: 24.08N to 16.58N
LON: 164.00W to 149.00W

Hurricanes/Tropical Storms within Selection Criteria:

Year	Name	Year	Name	Year	Name
1950	HIKI	1972	FERNANDA	1983	NARDA
1951	Tropical Storm	1972	DIANA	1983	RAYMOND
1957	KANOA	1973	DOREEN	1985	LINDA
1957	DELLA	1974	IONE	1986	ESTELLE
1957	NINA	1976	GWEN	1988	GILMA
1958	Tropical Storm	1976	KATE	1988	FABIO
1959	DOT	1978	FICO	1988	ULEKI
1959	WANDA	1978	MIRIAM	1989	WINONA
1962	Tropical Storm	1980	KAY	1989	DALILIA
1963	IRAH	1981	JOVA	1990	MARIE
1966	CONNIE	1982	DANIEL	1991	FEFA
1967	ELEANOR	1982	GILMA	1992	GEORGETTE

Hurricanes/Tropical Storms within Selection Criteria:

YEAR	NAME	YEAR	NAME	YEAR	NAME
1967	SARAH	1982	KRISTY	1992	ORLENE
1970	MAGGIE	1982	IWA	1992	INIKI
1971	DENISE	1983	GIL		

Figures 4 to 7 show the above storm tracks.

ADDITIONAL REFERENCE MATERIAL:

ALGERMISSEN, S.T. (1986) SEISMICITY AND DESIGN ZONATION IN HAWAII.

CHENG, E.D.H., and CHIU, N.L. (1992) COMPUTATIONAL METHODS FOR ESTIMATING EXTREME WIND SPEEDS.

CHOCK, G.Y.K. (1995) DEEP AND HIGH IN HAWAII, ASCE, CIVIL ENGINEERING, NOVEMBER.

COMMITTEE ON NATURAL, DISASTERS (1983) HURRICANE IWA, HAWAII.

COMMITTEE ON NATURAL, DISASTERS (1985) HURRICANE IWA, ALICIA AND DIANA COMMON THEMES.

DUDLEY, W.C. AND LEE M. (1988) TSUNAMI.

DURHAM, K. (1993) KILLER WAVES, OREGON GRADUATE CENTER - VISIONS.

EISSLER, H.K., and KANAMORI, H. (1986) DEPTH ESTIMATES OF LARGE EARTHQUAKES ON THE ISLAND OF HAWAII SINCE 1940.

ENVIRONMENTAL MANAGEMENT, ASSOCIATES, and INC.(1989) GEOTHERMAL RESOURCE PERMIT APPLICATION AMENDMENT FOR THE PUNA GEOTHERMAL VENTURE PROJECT.

FURUMOTO, A.S. (1972) USE OF HISTORICAL INFORMATION FOR ZONING AND MICROZONING IN THE ABSENCE OF INSTRUMENTAL DATA: CASE OF HAWAII.

HARAGUCHI, P.(1984) HURRICANES IN HAWAII.

HELIKER,C. (1990) VOLCANIC AND SEISMIC HAZARDS ON THE ISLAND OF HAWAII.

HONOLULU ADVERTISER (1992) HURRICANE INIKI.

KOBUKE, K. (1987) TRANSMISSION LINE WIND LOAD STUDY.

LOS ALAMOS NATIONAL, LABORATORY. (1994) VOLCANIC HAZARDS AND ENERGY INFRASTRUCTURE.

LUM, W.B., NIELSEN; N.N., KOYANAGI, R.; and CHIU, N.L. (1984) DAMAGE SURVEY OF THE KAOIKI, HAWAII EARTHQUAKE OF NOVEMBER 16, 1983.

MATTOX, T.N.(1995) WHERE LAVA MEETS THE SEA: KILAUEA VOLCANO HAWAII.

PERRY, D.C.; CHUI, A.N.L.; CHUI G.F.L, SCHROEDER, T.L; (1992) HURRICANE INIKI - PRELIMINARY OBSERVATIONS, WERC POST-DISASTER TEAM.

PIETSCHMANN, R.J.(1993) KAUAI, A YEAR AFTER INIKI.

RODRIQUES, D. (1993)DISASTER PREPAREDNESS CONFERENCE II.

UNIVERSITY OF HAWAII AT, MANOA(1993)HAWAII COASTAL HAZARD MITIGATION PLANNING PROJECT.

WYSS, M. (1986) REGULAR INTERVALS BETWEEN HAWAIIAN EARTHQUAKES: IMPLICATIONS FOR PREDICTING THE NEXT EVENT.

WYSS, M., and KOYANAGI, R.Y.(1992) SEISMIC GAP IN HAWAII.

APPENDIX B

The State of Hawaii Department of Business Economic Development & Tourism (DBEDT) Energy Division provided the following summary of the energy resources of the Hawaiian Islands.

Most of Hawaii's electricity generation is produced by oil-fired power plants. Until 1992, about 90 percent was oil-fired, but a major coal plant on Oahu and a geothermal plant on the Island of Hawaii reduced oil's share to 74 percent. Oil, however, is expected to remain the dominant fuel over at least the next 20 to 30 years as few plants will be retired, offering few opportunities for replacement by other energy sources. Oil-fired generation's advantages include availability of a wide variety of sizes to meet different needs on different islands, ease of transportation and storage of fuel, reliability, and, in many cases, lowest current cost.

The total generating capacity of the utility grid and projected demand growth on each island provides the greatest limitation to renewable energy project implementation in the next 10 years. There are simply no new major requirements for additional generation. It is important however, to consider the long term value of renewable projects in near term energy supply decisions because of the 30 to 50 year life of generation resources which may be put in place. Hawaii's options include coal and renewable energy. The following discussion is based upon other projects in the Hawaii Energy Strategy Program.

COAL The AES Barbers Point plant currently provides 180 MW capacity on Oahu. Coal can be used to further diversify Oahu's energy supply. The lack of economies of scale currently make coal less attractive for the Neighbor Islands. The long term price of coal is not expected to increase significantly and coal does not pose a spill risk.

WIND Hawaii has almost 23 MW of wind capacity. A number of viable wind projects already exist. In Hawaii and Maui counties, more electricity could be generated by proposed wind projects than the utilities can accept. On Oahu, large-scale projects have been identified, but additional wind projects are less likely because of land use constraints.

SOLAR Hawaii has the largest per capita use of solar energy. A number of other solar technology projects are close to being cost-effective under nominal conditions. Both solar thermal dish projects and photovoltaic tracking projects are close enough to being viable to warrant serious consideration. Capacity credit, time-of-day pricing, or tax credit changes could make these projects viable generation options in the next ten years even under nominal or conservative conditions.

Hybrid solar systems that use gas, biomass, or other fuels in conjunction with solar thermal heat are receiving considerable attention and may hold promise for Hawaii applications. These hybrid systems can operate as firm generating resources. Solar thermal troughs do not appear to be viable options for development in Hawaii unless significant cost reductions are achieved.

BIOMASS

Currently, Hawaii's sugar industry generates electricity using bagasse for its own use and for sale to the utilities. However, as the sugar industry is in decline, the production has virtually ended on Oahu and the Island of Hawaii. Biomass electric and biomass fuels are both promising technologies for Hawaii. In addition to offering the only firm renewable energy option that is commercially viable, biomass plantations allow the state to preserve a portion of its land in agricultural crops which provides valuable benefits to the state's residents and visitors (e.g., a visually-pleasing green belt). Biomass fuels offer the additional benefit of being transportable and more easily stored. (Project 3)

GEOTHERMAL

Geothermal energy conversion from high temperature water (>150 degrees Celsius) resources is a mature technology that has been commercially deployed since the 1960s. A 25 MW geothermal plant is successfully operating at Puna on the Island of Hawaii. The Kilauea east rift zone is a known high temperature hydrothermal resource area with potential for additional development.

HYDROELECTRIC

Hawaii has 20 hydro plants of 0.2 MW or more for a total of over 31 MW capacity. Many are run-of-the river and dependent on rainfall, so hydro is considered an intermediate resource. Additional hydroelectric projects are commercially viable in Hawaii today, however, a limited number of new developable sites exist.

LIQUIFIED NATURAL GAS (LNG) AND SYNTHETIC NATURAL GAS (SNG)

Natural Gas is not available in Hawaii. A recent analysis suggests that LNG is not currently an economic option. Extensive fuel substitution in the electric power and ground transportation sector would be needed to provide maximum economies of scale. Moreover, conversion from other fuels would need to occur simultaneously with the provision of an LNG supply. The infrastructure costs would be extremely high at about $5.8 billion and LNG would cost over two and a half times the cost of low sulfur fuel oil for an equivalent heat value.

Synthetic natural gas is produced for Oahu's gas system by BHP's oil refinery. Since SNG is an oil product, its use for power generation would not reduce Hawaii's oil requirements, but some use could more completely use the products of the crude oil currently imported.

MUNICIPAL SOLID WASTE

Oahu's H-POWER municipal solid waste plant (MSW) produces 60 MW. Of this capacity, 45 MW is available for sale to the utility. While Oahu's population continues to grow, current projections of the waste stream by City and County of Honolulu officials do not indicate near-term opportunities for increasing H-POWER capacity due to reductions through use of green waste and recycling. There may be opportunities for future MSW plants on Maui if costs can be reduced for smaller plants.

NUCLEAR

Nuclear power does not appear to be a near term option. Nuclear power plants are typically too large for even Oahu's electric system. In addition, safety zone, evacuation options, and waste storage problems do not appear to be solvable in the near term. Moreover, Hawaii's State Constitution requires Legislative approval of nuclear power; such approval appears unlikely.

OCEAN THERMAL ENERGY CONVERSION (OTEC)

OTEC produces energy and desalinated water. The only OTEC plant in the world is a 210 kW open-cycle experimental plant on the Island of Hawaii. OTEC may offer a significant contribution to Hawaii's generation mix in the long-term, but it is not expected to be competitive with other energy options in the next 10 years.