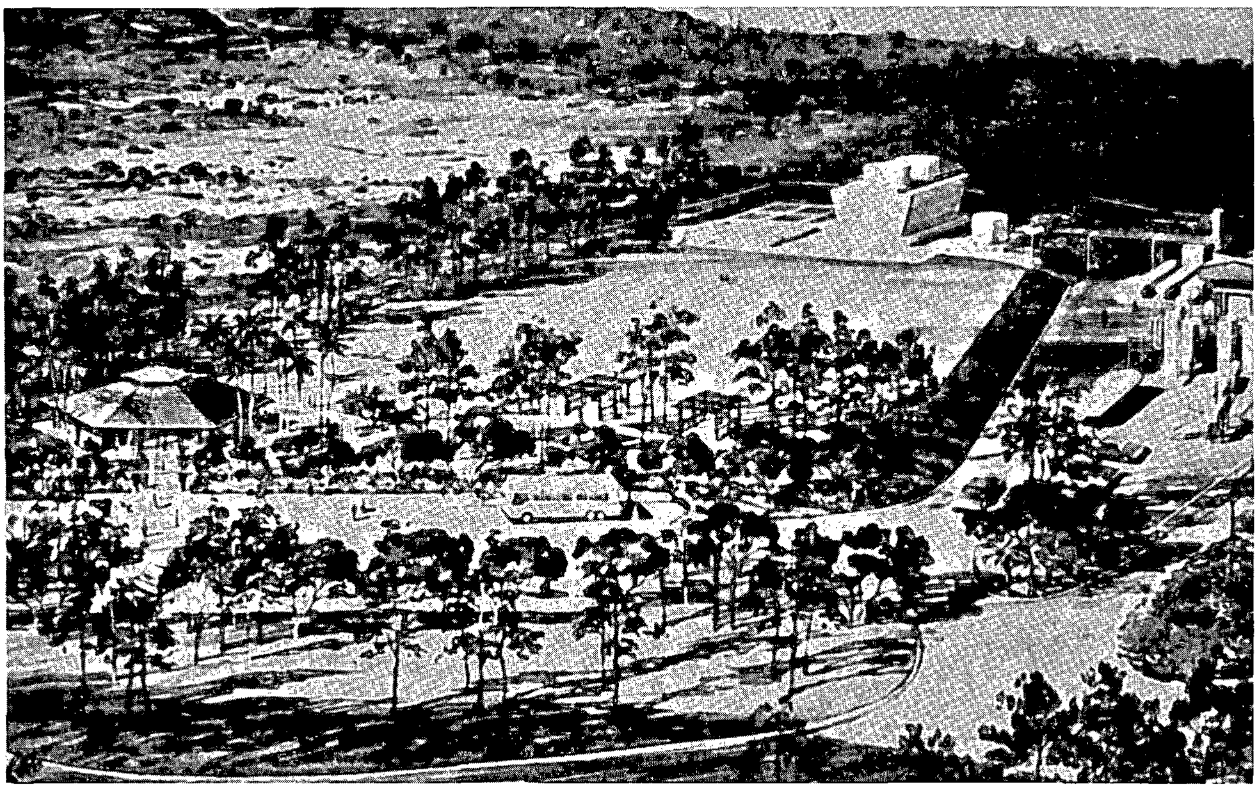
GL02494

HGP-A WELLHEAD GENERATOR FEASIBILITY PROJECT

The First Generation Of Geothermally-Produced Electricity In Hawaii Is Imminent



Drilling for geothermal energy in Hawaii began in the early 1960's on the Big Island. The initial four wells were drilled in the Puna District to a relatively shallow depth and were unsuccessful in reaching a producing geothermal resource. A fifth well was drilled in 1973 near Halemaumau Crater to a depth of 4140 feet. This well had a bottomhole temperature of only 279° F, but the sharp increase in temperature with depth near bottomhole suggested a very hot geothermal resource.

With the establishment of the Hawaii Geothermal Project in 1972, the University of Hawaii pursued an exploration and drilling program which led to the drilling of the first fluid producing well, HGP-A. The well, made possible by federal, state, county, and private assistance, was drilled near Kapoho in the Puna District to a depth of 6450 feet. It has a bottomhole temperature of 676° F making HGP-A one of the hottest geothermal wells in the world.

In order to demonstrate the feasibility of geothermal energy utilization, a geotheremal wellhead electric generator is being constructed. Rogers Engineering Company, Inc. of San Francisco is designing the geothermal power plant and providing construction management.

Because of the risk of volcanic eruptions, the plant is being designed so that specific pieces of equipment will be easily removable. The wellhead assembly also is designed for protection against lava flows.

The steam supply system consists of the wellhead, the cyclone separator which will separate the steam and the water, and another in-line separator to remove residual liquid contained in the steam. Steam will be supplied to the power plant at 52,800 lb/hr at 370°F and 160 psia. As the steam drives a turbine generator, 3 megawatts of power will be produced. Approximately 0.2 megawatts of the electricity generated will be used for plant operations, leaving 2.8 megawatts which can be sold to the local utility, Hawaii Electric Light Company.

The steam is discharged from the turbine into a condenser where it is transformed to liquid. The cooling water used in the condenser comes from the geothermal fluids. The water absorbs the heat from the steam and is sent to a cooling tower where the heat is dissipated into the atmosphere by evaporative cooling.

During this process the noncondensible gases are separated from the liquid and removed. The gases flow to an incineration system where the hydrogen sulfide gas is treated with caustic soda to abate the rotten eggs smell.

Every effort has been made to provide the necessary environmental controls to limit air, water, and noise pollution. Furthermore, the architectural treatment and landscaping will enhance the natural surroundings of the well site. To insure the program effectiveness, a comprehensive monitoring program will be carried out by Analysis Laboratories of Richmond, California.

Meanwhile, the commercial drilling of geothermal wells in Hawaii has been initiated by a few private companies. A partnership between Barnwell Industries and the Geothermal Energy Development Corporation has completed drilling one well known as Ashida Well #1 and plans to drill several more. Two other consortia have leased land in the Puna District and have stated their intentions of drilling. Interest in drilling in other areas and on other islands also has been expressed by private firms. Commercialization of geothermal energy is quickly becoming a reality.

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OIL FROM ALGAE

Phaeodactylum In Raceways Can Be Harvested For Oil And Protein

Phaeodactylum, a type of algae, is 75 percent lipid and protein, and as such could be harvested and used in the production of oil. An initial laboratory study in 1977 estimated that with proper harvesting techniques, one acre of phaeodactylum could yield 150 barrels of oil per year. The resultant oil could be refined or processed and used as liquid fuel, in the petro-chemical industry, or in any other forms deemed valuable.

A continuation of the initial study is ongoing now at Snug Harbor on Oahu. Entitled "RD&D of Algal Production Raceway Systems for the Production of Hydrocarbons," its purpose is to design and construct a system for growing and harvesting phaeodactylum tricornutum.

Air is bubbled through the system now to mix the algae, insuring equal exposure to sunlight, and providing the CO_2 needed in the production of this strain of algae. The raceway system being built will allow for continuous harvest as algae moves throughout the system.

Eventually the heat from algal production will be absorbed and used to generate electricity, and protein will be recovered as well as will oil. This is the plan for a large-scale working system, but first, production and harvesting methods must be tested.

If the results of this raceway project are promising, Pacific Resources, Inc., the Solar Energy Institute, and the State of Hawaii will fund further tests in this four phase projects. Some of these will involve cost analysis studies, market development, and assessments of the value of the oil and protein produced.

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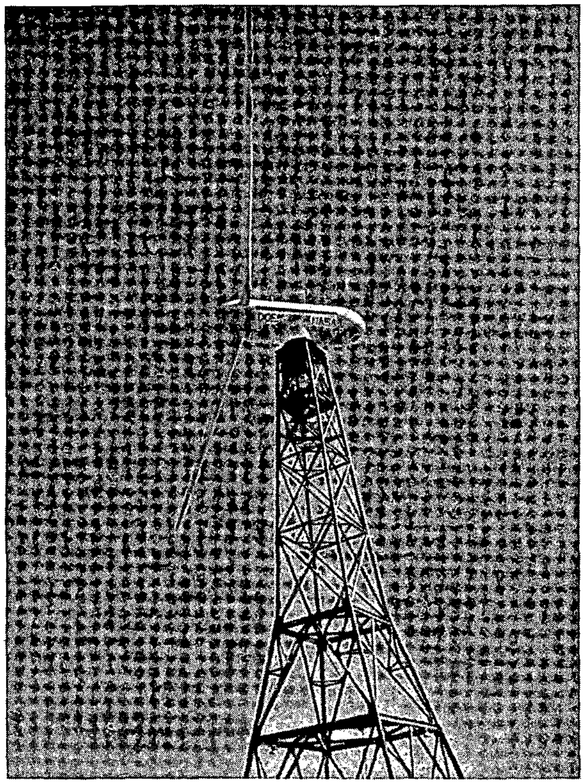
MOD-OA
MAKANI HUILA

A $2 Million Wind Machine Is Expected To Replace 1900 Barrels Of Oil Per Year



In early summer of 1980, a 60,000 pound wind generator was lifted into place atop its 100 foot support tower, blessed, dedicated, and named Makani Huila (Hawaiian for wind wheel). By late summer, Makani Huila, a 200 kilowatt MOD OA, reached 1000 hours of successful operation and was producing electricity 85 percent of the time that the winds were strong enough.

The turbine turns at a speed of 40 rpm, its synchronous speed. Because allowing the blade to turn with a low speed wind may actually take energy from the utility, the blades are feathered to prevent turning in less than 13 mph winds. Because winds which are too strong can cause dangerous current fluctuations and put too much stress on the blades, the blades are feathered to prevent turning in winds stronger than 32 mph. At wind speeds between 13 and 32 mph the pitch angle of the blades can be varied to obtain maximum energy from the wind while keeping the rotation speed constant.

The Makani Huila blades are made of a wood composite, except for the steel root end spool pieces. Blades on the previous MOD OAs were made of aluminum, but it was discovered that wood can handle stress better. The MOD OA blades, shaped like conventional airplane wings, sweep a diameter of 125 feet.

The rotor hub connects the blades to the shaft and also houses the pitch change mechanism. The hub holds the blades very rigidly, and permits only the freedom of movement needed for pitch change, a maximum of 8 degrees per second.

When the wind turns the blades it turns a low speed shaft. The power is transmitted through the low speed shaft to a 1 to 45 fixed ratio gearbox, which transmits the power to a high speed shaft. This power is then passed to the generator through a fluid coupler.

The entire machine can be turned on top of the tower so it is always facing downwind. This side to side movement, called yawing, is accomplished at a rate of 0.4 degrees per second. When the cut-in speed is reached the machine will yaw to position itself automatically.

The Makani Huila comes equipped with a disk brake and a fixed yaw brake. It is mounted on an open truss tower made of round pipe, which is anchored to a 5 foot deep concrete slab foundation.

The MOD OA control system provides for the safe and reliable operation of the wind turbine at a remote, unattended site and performs the following functions automatically:

- controls the production of electric power over a wide range of wind velocities,
- aligns the rotor assembly with the wind direction, and
- protects against damage due to abnormal operating conditions and/or extreme environmental conditions.

Operated and maintained by the Hawaiian Electric Company, this U.S. Department of Energy funded project will be a determination of just what effect the 200 kilowatts will have on a utility system. How well the electricity is synchronized with the utility grid, how corrosion affects the workings of the wind generator, and how often it produces how much electricity will be learned.

The demonstration is extremely successful to date, primarily because of the excellence of Hawaii's winds. The average wind speeds at Kahuku are 20-24 mph, far above the national average. It has been estimated that a MOD OA will generate electricity approximately 50 percent of the time, but in Hawaii the percentage has been much higher. This is because in Hawaii, the winds are much stronger and more consistent.

Below the MOD OA is a seafood plantation, producing oysters and other aquacultural products. The grounds of this plantation, however, serve a dual purpose. They are used as an applications center for wind energy conversion systems. Presently, a unique wind-powered water pump is being tested at the plantation. The water pump, patent pending, is designed to increase the volume of water pumped to three times the normal rate. This is accomplished by varying the length of the stroke rather than the rate of pumping.

A small, two-kilowatt Dunlite machine also is operating at the Kahuku Seafood Plantation, and will eventually be connected to the utility grid for tests on synchronization.

Additionally, a 15 kilowatt United Technologies Research Center machine is providing the power required to produce nitrogen fertilizer. Future plans include a possible 10 to 15 wind machines of varying sizes being demonstrated at the plantation.

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SUGAR MILLS ON HAWAII

Bagasse, A By-Product Of Sugar Cane Processing, Is The Plantation's Main Source Of Fuel

A total of thirteen sugar plantations, 210,007 acres, produces approximately 1,100,000 tons of raw sugar and 1,500,000 dry tons of bagasse per year. Bagasse and supplemental fuel oil provide almost all of the boiler fuel needed to produce the steam used by the mills for electricity generation and for various other plant processes. Electricity generated in excess of the mill requirements is sold to the local utility for redistribution and resale.

A warm sunny climate and an adequate water supply are the natural resources which help make Hawaii a natural sugar producer. In fact, Hawaii supplies approximately one-tenth of the sugar used in the United States.

Sugar was already growing in Hawaii when the English explorer, Captain James Cook, landed in 1778. The early Hawaiians used sugar cane as hedges or wind breaks, and would break off the stalks and chew them for the sweet juices inside. Anthropologists believe that the Polynesians brought sugar cane with them when they came to Hawaii in approximately 5 A.D.

The first recorded sugar plantation in the islands was started in Manoa Valley on Oahu in 1825, but it failed within two years. The failure was not the end of sugar in Hawaii, however, and another plantation was begun in 1835 at Koloa, Kauai. This plantation continued and is now part of the McBryde Sugar Company.

The sugar cane plant itself is a giant member of the grass family and is propagated by planting pieces of the stalk. This is called "seed" cane and consists of sections about two feet long. In Hawaii, most sugar cane is harvested after two years. A few weeks prior to harvesting, the field is allowed to dry, then the cane is pushed back from the roadways and firebreaks are made. The field is set on fire to burn the millions of dry leaves that have fallen. The fire is hot and quick, lasting only a few minutes. Because the cane stalks contain much water, they are not harmed, and once the fire is out they are harvested.

At the mill, the sugar cane is washed to remove soil, leaves, and rocks. After the cane is cleaned, it is shredded in preparation for milling.

The sweet juice is removed from the shredded fiber by squeezing or pressing the stalks. The juice is then clarified, evaporated, and crystallized.

The clarifiction process is accomplished by adding lime to the juice, heating it, and allowing it to settle out. The clear juice is evaporated, leaving behind a thick dark syrup. Boiling this syrup and adding tiny "seed crystals" produce larger sugar crystals. The heavy dark mixture of crystals, called massecuite, is transferred to centrifuges which spin at a rate of 1800 revolutions per minute, thus separating the liquid molasses from the sugar crystals. Most of the molasses is shipped to the Mainland or used in Hawaii as cattle feed, but there is a larger potential market for its use as the feedstock in ethanol production. The resultant ethanol would be very valuable as liquid fuel.

The fiber left after the juice removal is bagasse, used to provide the electricity needed for the mill operations. The excess electricity is sold to the local utility, and helps replace imported petroleum as a fuel. On Kauai and Hawaii for example, much of the electricity consumed is derived from bagasse.

The main product of the sugar mill, however, is a handsome golden brown raw sugar ready for shipping to the California and Hawaiian (C and H) Sugar Company for refining into table sugar.

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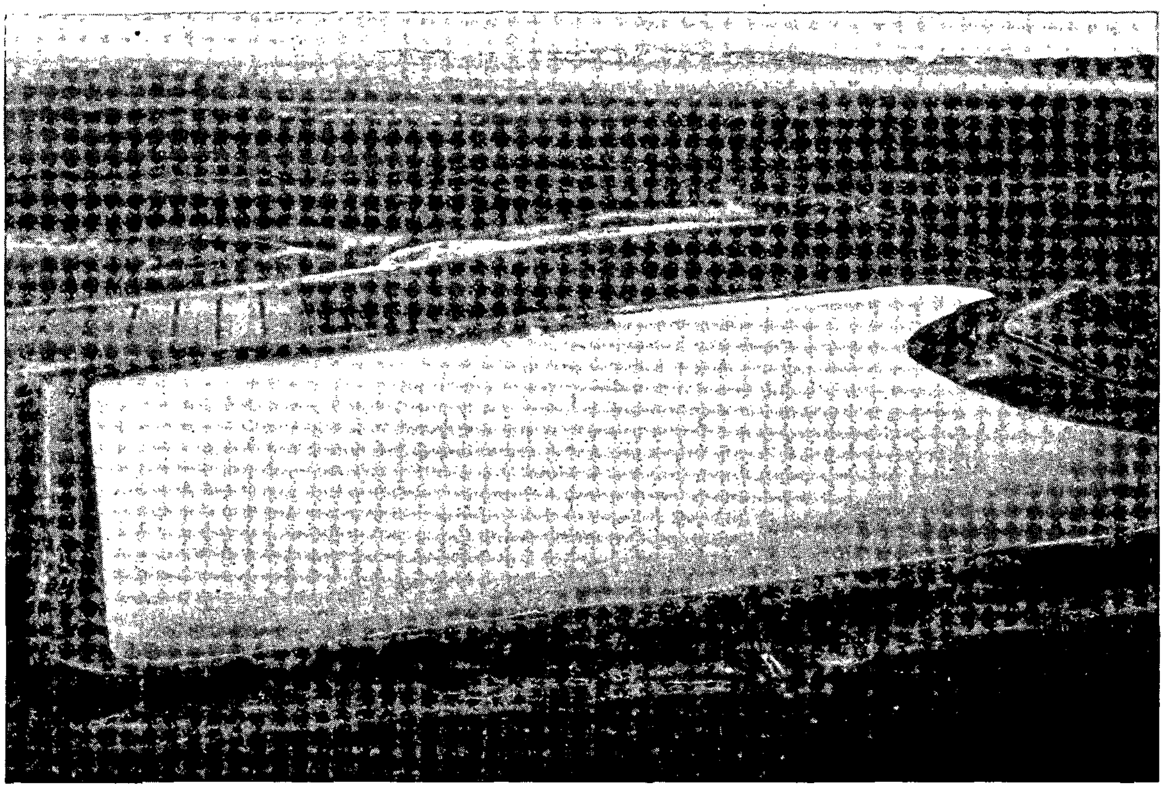
MOLOKAI ENERGY PROJECTS

Electrical Energy Self-Sufficiency For Molokai Is Proposed For 1983



The island of Molokai is a distinct community of small towns and rural residences. Molokai Electric Company, Ltd. is the only commercial electric power generator on the island, and has a peak demand of about 5 megawatts. Because there is no connection to any external power grid, and because Molokai has no sugar cane bagasse for electricity generation, Molokai consumers pay a rate of nearly 15 cents per kilowatt hour for electricity. This is one of the highest rates in the nation.

Molokai, however, has many natural energy resources including biomass, direct solar, hydroelectric, and wind. (See additional fact sheet for description of wind projects). The biomass resources are primarily hay and dried pineapple plants. Molokai Electric Company plans to install an biomass steam boiler which could, with sufficient biomass fuel, contribute up to 60 percent of Molokai's electricity needs. The boiler will burn hay, and dried pineapple plants if they are available when it goes on line. If biomass resources are not available, coal can be burned as an interim step. As part of a proposal, "Hawaii Energy Self-Sufficiency Program—Priority One: Electrical Energy Self-Sufficiency," a second biomass boiler is requested.

The amount of hay purchased by Molokai Electric Company could supply up to 10 million kilowatt hours per year. Discussions and initial plans also are underway for burning leucaena or eucalyptus wood chips in the boiler. Additionally, if the approximately 900 acres per year of dried pineapple plants were available, they could supply about 16 million kilowatt hours per year.

Projects also being considered to make Molokai electrically self-sufficient by the beginning of 1984 include planting a giant koa haole tree farm, maximizing the use of solar heaters, installing three vertical axis wind turbine generators, installing a gas turbine, and collecting social and environmental baseline data.

Molokai Electric Company Company Ltd. is the recepient of a DOE award for the "Small Community Solar Thermal Power Experiment: Site Participation." The site being developed is part of a 50 acre plot at Palaau, Molokai. The new biomass generating facilities will be located there also, but fifteen acres have been set aside for the solar project.

In this solar system, the sunlight will be collected by as many as 23 dish concentrator modules and directed to the center of each one. A receiver unit is mounted near the concentrator focus and a heat exchange medium such as sodium transfers heat to a working gas, helium. Helium gas then operates an electricity producing engine.

Each of the dish modules will be approximately 16 meters, or 18 yards in diameter, and 23 of them could produce up to 1 megawatt, or one-fifth of Molokai's electricity needs. Before approval for plant construction can be granted, however, site data development must be completed. Installing solar and wind measurement equipment, identifying and obtaining permits, collecting environmental and socio-economic impact data, evaluating the data collected for its impact on the solar plant, and preparing quarterly reports are part of Task I. All of this work is being performed by HNEI. Mr. Bruce Yamashita, Executive Vice President and General Manager of Molokai Electric Company, Ltd. is project manager, and HNEI, Thermal Engineering Company, and ECM, Inc. are subcontractors.

Hydroelectric also could have potential on Molokai if the Kualapuu Reservoir is used. A power plant could be located below the reservoir, the water would flow down and generate electricity. During non peak times the water would be pumped back to the reservoir, preferrably by wind powered water pumps, and allowed to flow down again when needed.

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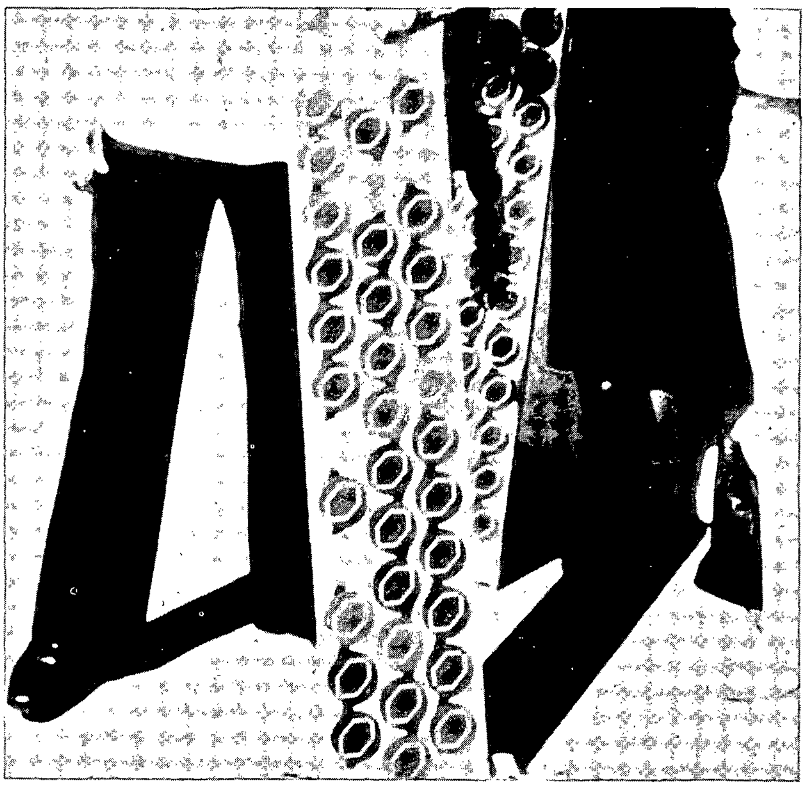
SOLAR PANELS AND COLLECTORS

Rooftop Panels Ease Electricity Costs



A "Research Experiment in Rooftop Mounting of Photovoltaic Systems on Lived-In Units in Hawaii" is ongoing using state-of-the-art glass enclosed solar panels, each containing 35 four inch silicon cells. These panels are being mounted onto three rooftops in Hawaii beginning with the home of Mr. and Mrs. Antonio Evangelista in Kalihi, Oahu. The Evangelista's home is half of a two story frame duplex, about ten years old. The roof is a simple shed type, facing south, with asphalt shingles and an available area of approximately 400 square feet. The 20 degree slant of the roof is thought to be the correct tilt for photovoltaic arrays in Honolulu. A two kilowatt peak array is being tested, with the power produced being used in the household and the excess, if any, sold to the utility. The Evangelista's monthly electric bill is just under $50, and will be either reduced or eliminated totally.

The home of Mr. Henry Wiebke on Molokai also has been selected to test photovoltaic cells on residential rooftops. A four kilowatt array on a 700 foot area should reduce appreciably Mr. Wiebke's $110 monthly utility bill. Another four kilowatt array has been designated for the third experiment, an as yet unoccupied home in a new Pearl City, Oahu, development.

DOE and MIT Lincoln Laboratories are working with HNEI on this project, and ARCO Solar has been contracted to design and install the rooftop panels. The Hawaii Housing Authority, Molokai Electric Company, and Hawaiian Electric Company also are cooperating in this experiment. This project will provide answers to how well a photovoltaic system functions as an energy source for modern live-in residences. Small electric appliances, power tools, deep freezers, washers and dryers, televisions, stereos, and other modern conveniences are part of these households and their usage will not be interrupted. The Pearl City and Molokai systems will have separate solar water heating systems, while the Kalihi unit uses gas for water heating and cooking.

Other rooftop installations in Hawaii are solar water heating systems, which have become commercially available and affordable through tax credits and energy savings. Hawaii has approximately 13,000 residences and other buildings using solar water heating, which makes it the state with the largest number of solar water heaters per capita.

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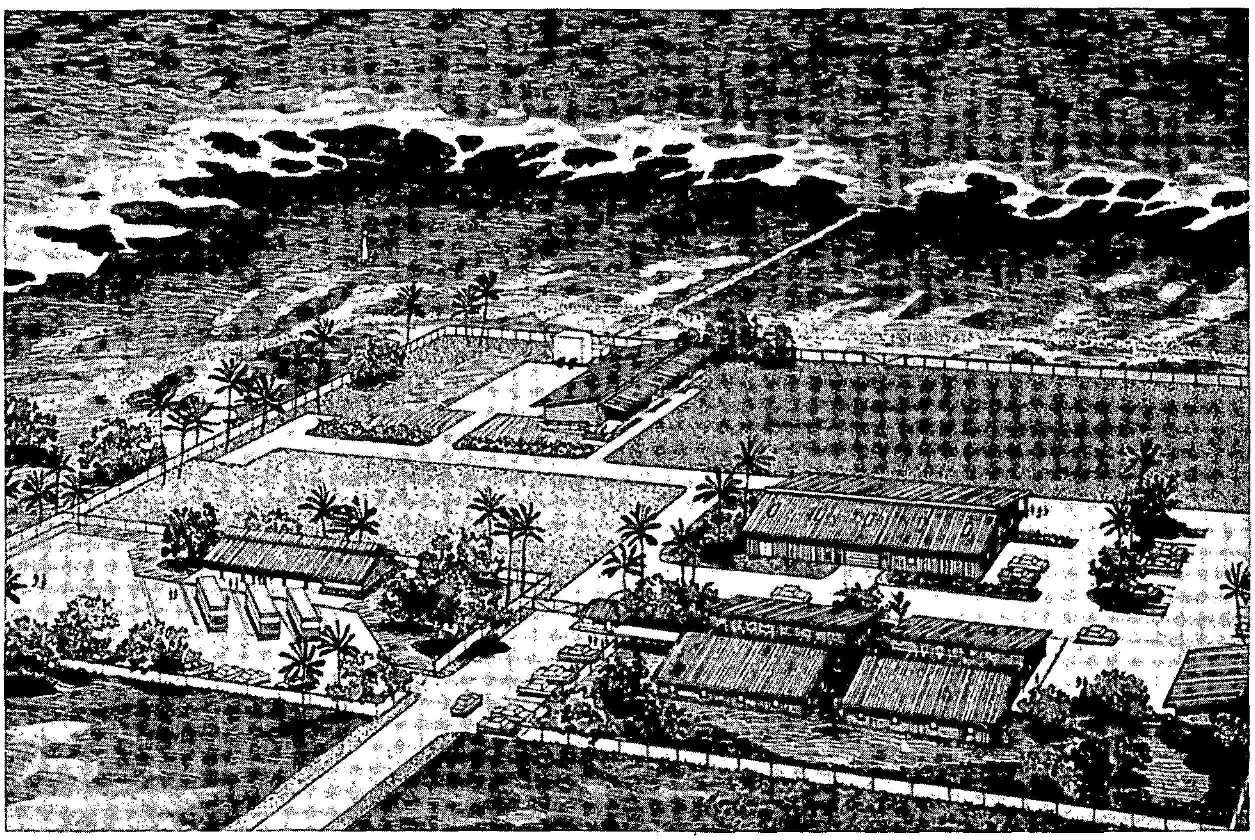
OTEC SEACOAST TEST FACILITY

A Center for Excellence in
Ocean Energy Research



The Seacoast Test Facility (STF) is an onshore research and development laboratory for ocean thermal energy conversion (OTEC) and OTEC-related projects. Studies of biofouling and corrosion of heat exchangers of all sizes, system component testing, and research on both open and closed-cycle OTEC systems will be conducted at the completed STF. As a merger of projects, funds, ideas, and researchers takes place at STF, Hawaii can become the world's focal point for ocean energy research.

STF is located at the Natural Energy Laboratory of Hawaii (NELH) at Ke-ahole Point, Hawaii. This area has the following desired characteristics available or readily attainable:

1) Deep ocean water is available approximately one mile offshore.
2) A year-round temperature differential in excess of 35° F exists between the deep cold water and the warm surface water.
3) Historical evidence suggests that there is very little risk of severe tropical storms, hurricanes, earthquakes, or volcanic activity.
4) The state owned land is available indefinitely.
5) Utilities, transportation, personnel housing, and other living facilities are available nearby.

6) A master plan for the required NELH site improvements has been completed and approved, and design and construction can be accomplished on a reasonable time schedule.
7) Most of the necessary environmental impact statements and permits have been approved.

The STF onshore facilities presently consist of a basic test pad and an adjacent building to house the control room and instrumentation laboratory. Both the pad and the building have been designed for easy expansion. Currently under construction is the power center, and an office building and warehouse also are planned.

A temporary warm water supply system pumps water at a rate of 1000 gallons per minute through two 12 inch pipes. Ultimately STF will be equipped with both warm and cold water pipes, at least 32 inches in diameter. The warm water pipe will be capable of pumping at least 9600 gallons a minute, while the cold water pipe will pump at least 6400 gallons a minute.

Argonne National Laboratory has funded proposals for biofouling and corrosion research and for the installation of special testing apparatus to continue this research. The project objective is the evaluation of various materials and fouling countermeasures for ocean thermal energy conversion heat exchangers. Candidate materials include aluminum, titanium, and stainless steel.

The countermeasures studied will be mechanical types such as brushes, sponge rubber balls, and abrasive slurries. Chemical means such as chlorine will also be evaluated.

Experimental hardware and facilities have been and are being installed at STF for these tests. They include boost pumps and associated hydraulics for the heat transfer measurement models, a data control and acquisition system, an environmentally controlled room within a laboratory building, and instrumentation for the water quality testing.

Other projects and proposals will soon be ongoing at STF, but biofouling and corrosion countermeasures remain very important to the OTEC program.

Studies on open-cycle OTEC systems and aquaculture also are planned for STF. Open-cycle OTEC is an example of a system that has by-products as valuable and as beneficial as the original purpose. Open-cycle systems produce electricity, but they also produce fresh water, which is as important as electricity in some areas. Similarly, a beneficial side-effect of bringing cold water to shore for OTEC experimentation could be an aquaculture system. Prawn, oyster, and opihi, among others, must be cultivated in cold water, and a preliminary study of installing an aquaculture system at STF is underway.

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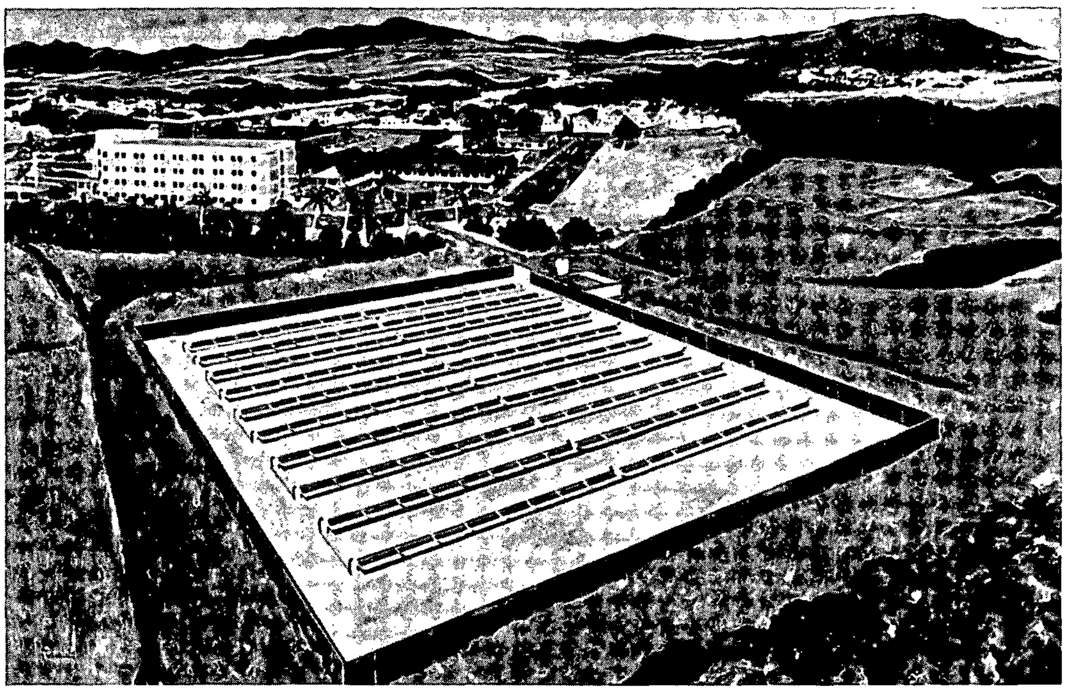
PHOTOVOLTAIC SYSTEM FOR KAUAI'S WILCOX HOSPITAL

The Largest Photovoltaic System In The State Provides Both Electricity And Hot Water



A photovoltaic system, capable of producing up to 40 kilowatts of electricity, is being installed at the G.N. Wilcox Memorial Hospital on Kauai. Funded by the U.S. Department of Energy and the State of Hawaii, the project has the participation of HNEI, Kauai County, Kauai Electric Company, Wilcox Hospital, and Acurex Corporation, the system designers.

Concentrating solar photovoltaic collectors, a power conducting system, a thermal recovery and cooling system, and an automatic instrumentation and control comprise the Acurex photovoltaic system. The concentrator/collector module is composed of a parabolic trough reflector which will automatically track the sun, ensuring that all available sunlight is focused onto the photovoltaic cells. The cells line the underside of a rod which is centrally positioned over the parabolic trough. Five rows of collector modules will be installed in a 100 ft x 170 ft area, south of the main hospital building.

Electricity produced by photovoltaic systems is in the form of a direct current, DC, and must be transformed into alternating current, AC, if it is to be integrated successfully with other electricity coming into the hospital. This will be accomplished by the power conditioning system. Electricity produced by this system will be fed directly into the hospital's electrical network in parallel with that from the local utility grid.

Because much of the energy from photovoltaic cells is given off as heat, a cooling system, consisting of water sent through the hollow rod containing the cells, will be installed. Thermal energy from the cells will be transferred to the water, resulting in the beneficial by-product of hot water. The Wilcox Hospital on Kauai will use most of the hot water to supplement that used for laundry, cooking, and bathing purposes. Between 50 to 75 percent of the hospital's hot water will be supplied by the photovoltaic system.

This system is one of the nation's first large-scale demonstrations of photovoltaics, and Hawaii's largest solar energy project to date. It will demonstrate the potential of photovoltaic systems, thus paving the way for widespread use of photovoltaics in the future.

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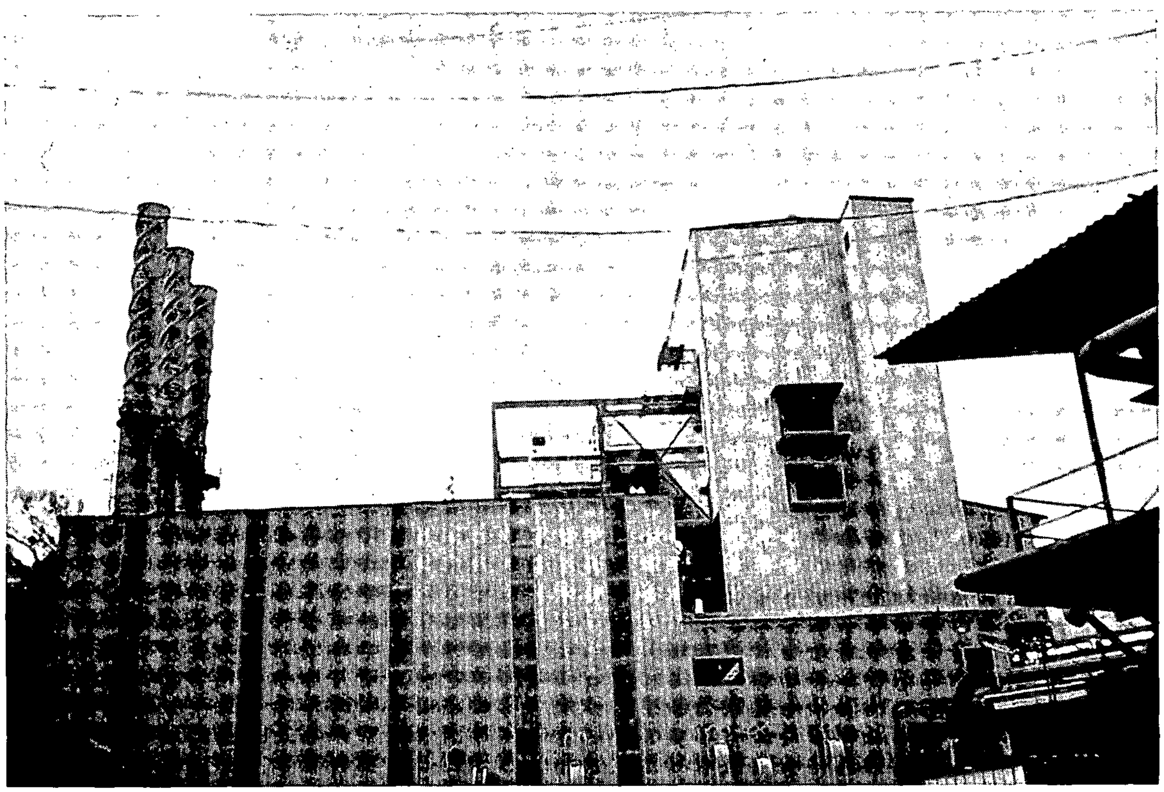
LIHUE BAGASSE BOILER

The New Plant Guarantees Kauai Electric A Reliable Power Supply



Bagasse boilers are not new in Hawaii. In fact, sugar plantations rely upon the electricity produced by the bagasse burning to provide most of their electrical needs, selling any excess to the local utility. The new bagasse boiler in Lihue is special because of its emphasis; it was built with the utility as well as the plantation in mind. The new plant has enabled the utility to defer buying a new oil-fired generating plant.

Lihue Plantation also benefits from the new power plant. The boiler transforms its power production from aged and obsolete facilities to the latest in generating equipment. For years the company had been feeding its bagasse into brick boilers with a heat transfer efficiency of less than 10 percent. The new plant is 69 percent efficient, so that a ton of bagassse now produces the equivalent of a barrel of oil.

The boiler has a 12 megawatt capacity, and Lihue Plantation has contracted to sell to Kauai Electric 12,000 kilowatt hours of power a week for 48 weeks a year, or a minimum of 55.6 million kilowatt hours a year.

The new bagasse boiler is owned by Foster Wheeler Kauai, Inc., a wholly-owned subsidiary of Foster Wheeler Corporation, New Jersey. Foster Wheeler and Lihue Plantation have entered into a contract guaranteeing Foster Wheeler all revenues from the plant up to the minimum utility purchase, 55.6 million kilowatt hours a year. Beyond that, the company will split the revenues with Lihue Plantation. In return, Lihue Plantation will operate the plant and will receive 8000 kilowatt hours a week—the required amount for the mill's processing needs.

Kauai Electric will pay Lihue Plantation varying rates which are tied to the Consumer Price Index and an oil escalation index. Two years ago the contract was signed, and the cost of the first 55.6 million kilowatt was 2.6 cents per kilowatt hour. Now, it's more than 4 cents per kilowatt hour.

Because of the escalator clauses in the contract, the electricity produced by the plant is not less expensive than electricity produced by oil burning. The rate of increase, however, may be less. More importantly, private industry rather than the utility is absorbing the depreciation costs of the plant.

Because it processes sugar cane only 10 months a year, Lihue Plantation supplies only 250,000 tons of bagasse. The boiler can handle more than this, so conversion is being contemplated which will enable the burning of wood chips, municipal waste, dewatered cane trash, and even shredded tires.

The total cost of the boiler was approximately $25 million but it reduces oil consumption by an estimated 100,000 barrels a year. This is a savings of $3 million a year. If and when other biomass fuels are burned, oil usage could fall by 200,000 barrels, and the savings would double.

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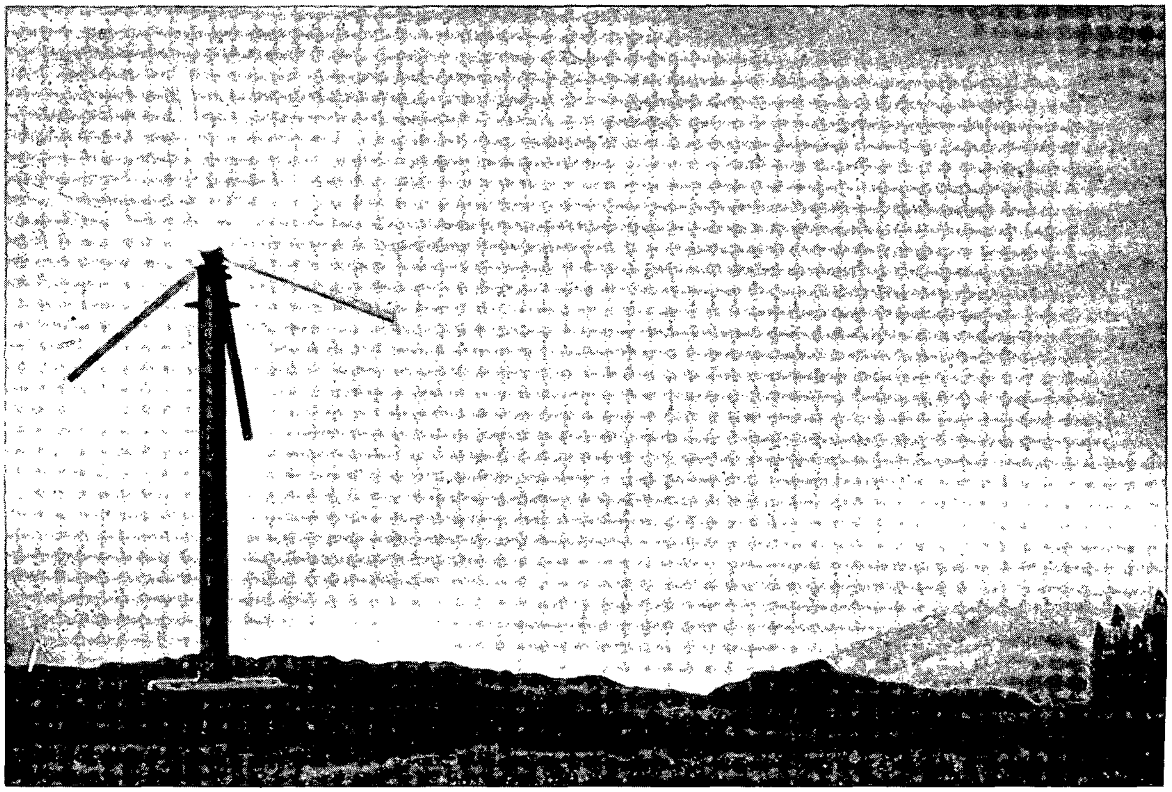
40 KW MEHRKAM WIND TURBINE

Energy Of The Future Is Available Today



A Mehrkam wind turbine with a 40 kilowatt capacity was installed at Kahua Ranch on the Big Island of Hawaii in the Spring of 1980, as part of the U.S. DOE Field Evaluation Program. The primary objective of the field evaluation program is to identify barriers to the commercialization of wind machines, including any institutional, legal, technical, environmental, and social concerns. Stimulation of the small wind energy conversion system industry also is a program objective. The Mehrkam 40 kilowatt machine was selected as one of the two machines tested in Hawaii.

The four-bladed Mehrkam is designed to rotate slowly as a method of insuring the machine's long life. The unit should begin operating at 5 mph winds, and shut-off at 40 mph. Greater output in this machine, as in most others, is obtained by increasing the size, not the speed, of the blades. The 60 foot tubular steel tower comes equipped with climbing rungs and a platform making repairs easy to handle. Additionally, the Mehrkam has automatic yaw control to assure proper orientation so that the tempered steel blades face downwind at all times.

The Mehrkam machine at Kahua Ranch has had some problems, and in fact has been replaced twice. The winds at Kahua may be stronger than the Mehrkam can handle, or other system malfunctions may be the cause. This project, however, is meant to be a demonstration and a test of the equipment, and as such is very successful. Monte Richards, Manager of Kahua Ranch, is overseeing the Mehrkam operation.

The second Mehrkam installed in Hawaii is on Molokai near Ilio Point. This machine was erected by a private firm, Molokai Energy Company, which plans to erect two or three more.

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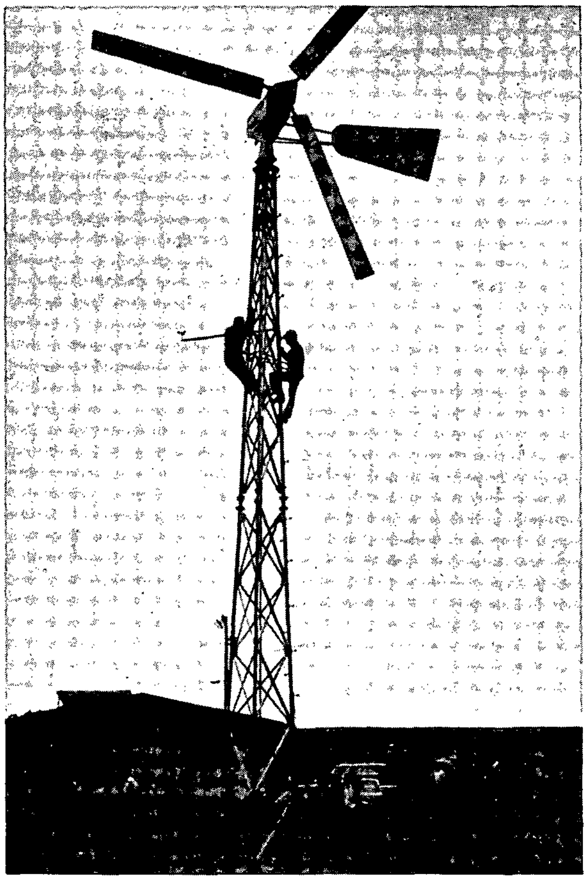
WIND MACHINES FOR MOLOKAI

Two Small Wind Energy Conversion Systems Are Producing Electricity For Molokai Now



A Millville wind energy conversion system (WECS) has been installed on the Hawaiian Homestead Commission land of Bucky Davis on Molokai. The WECS, with an estimated capacity of 10 kilowatts, has been producing an average of 23.91 kilowatt hours a day, or just under 1 kilowatt per hour. This is slightly more than the family uses.

The Davis family usage has been 423 kilowatt hours per month, 133 kilowatt hours of which are produced by the utility, while 290 kilowatt hours are produced by the WECS. The reason why some of the electricity used by the household is produced by the utility and some by the WECS, is that production and demand are not always equal. When demand exceeds production, for example between 5 and 9 pm, the utility must provide the energy needed. When production exceeds demand, such as weekday morning hours, the WECS provides electricity to the utility. In this case, the amount supplied to the utility is 426 kilowatt hours per month. A total of over 700 kilowatt hours a month are being produced by the Millville machine in Molokai's wind regime.

The Millville is part of the U.S. Department of Energy's Field Evaluation Program for small WECS. The program objective is to demonstrate technically available WECS to determine what problems, technological or non-technological, exist. Another small WECS, also erected as part of the field evaluation program, is on the Big Island.

The other small WECS on Molokai is operating in the best wind regime on the island, between Ilio Point and Moomomi Beach. This WECS demonstration is different because the machine, a 40-kilowatt Mehrkam, has been installed and funded entirely by private industry. Molokai Energy Company of California is the installer and intends to erect more of these on Molokai in the near future.

Another private company, Windfarms Ltd. is considering placing a number of vertical axis wind turbines (VAWTS) on Molokai. These VAWTS could be Alcoa Darrieus machines, capable of producing 500 kilowatts.

Wind is a potentially large resource for Molokai and other projects which utilize its power are being planned. A wind-battery storage project and a wind-powered pumped-storage project will both accelerate Molokai's achievement of energy self-sufficiency.

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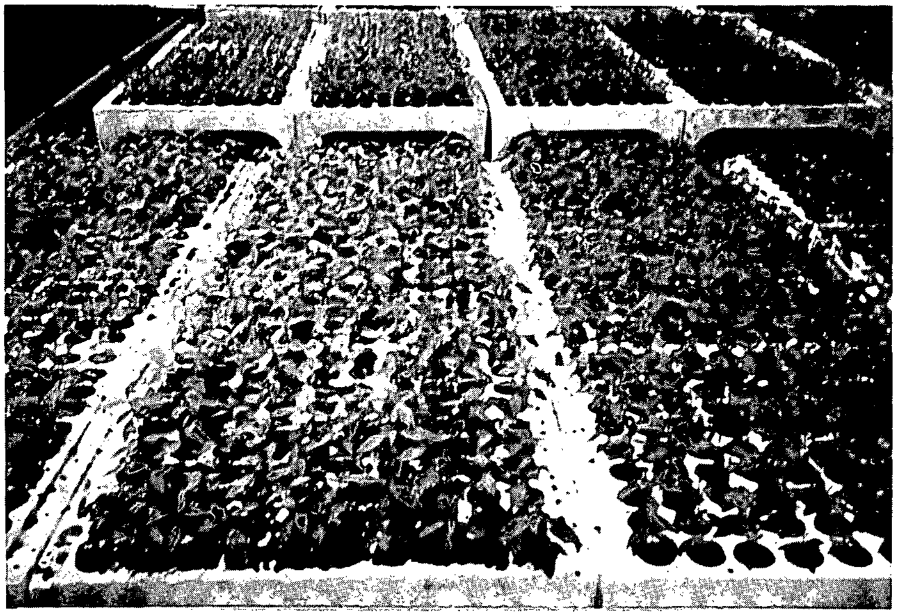
EUCALYPTUS PLANTATIONS FOR ENERGY PRODUCTION IN HAWAII

The Most Promising Source Of Additional Biomass Fuel Is Wood Fiber



There exists in Hawaii an urgent need for additional domestic energy sources to reduce our dependence on imported oil, and to supplement existing supplies of biomass fuel, chiefly bagasse—a by-product of sugar cane processing.

Sugar cane mills in the past have burned bagasse to produce electricity and steam for internal energy needs, and have sold any surplus power to the local utility. Most of the sugar cane factories have formal contracts to supply electricity to public utilities on a regular basis; by 1978 almost 40 percent of the Big Island's electricity came from bagasse.

Because of the obvious advantages of using agricultural by-products as biomass fuels, increasing interest is developing throughout Hawaii for greater biomass for energy production.

For this reason, on September 28, 1978, C. Brewer and Company, Ltd.'s BioEnergy Corporation and the U.S. Department of Energy entered into a cooperative agreement to demonstrate the feasibility of developing eucalyptus plantations for energy production in Hawaii. The U.S. Department of Agriculture is now funding the project. Energy plantations such as this are designed to obtain optimum utilization of every square foot of growing space as quickly as possible. Total yield per acre is more important than individual tree growth.

At the same time, every phase of the operation must be subjected to economic considerations. Trees, then, are grown as are other crops such as sugar, using every commerically feasible practice to insure return on investment.

The objective of BioEnergy's project is to answer the following questions:

1. How do different sites, cutting cycles, spacings, and cultural practices affect the yield and profitability of eucalyptus tree farms?
2. Will periodic monitoring of growth using chemical and physical tests provide guidelines to produce maximum yields?
3. Can genetically superior eucalyptus planting stock be identified and mass produced within a short time frame?
4. Which species of eucalyptus will prove best adapted on planting sites differing greatly in elevation, rainfall, and soil properties?
5. Can existing equipment used to plant and cultivate eucalyptus seedlings, and to haul wood fiber to generating plants, be modified at minimal costs?
6. What is the optimum mixture of eucalyptus wood chips and other biomass fuel sources in a biomass boiler?

BioEnergy's project is planned five-year demonstration using a total of 850 acres (500 acres on the Hilo Coast and 350 acres in Ka'u). Its purpose is to determine the potential of eucalyptus farming as a means of producing wood chips for fuel.

A second energy tree farm project is underway at the Central Tree Nursery at Waimea, Hawaii. This nursery has been in operation since 1962, but was not involved in the cultivation of hardwood trees for energy at that time. Now, with the energy crisis so evident, the State Department of Land and Natural Resources, Division of Forestry, is interested in the energy value of wood chips.

Approximately 750,000 seedlings per year are produced at the Waimea Nursery. Hardwood seedlings, it was discovered in 1977, grow stronger and better when containerized planting is done. Expansion of containerized seedlings, that is seedlings grown in plastic containers for protection and ease of transplanting, was authorized by the 1978 Hawaii State Legislature for energy tree farms.

The implementation of these energy farms actually began in July 1980 when funds were made available. A continuing appropriation of $500,000 per year to provide for the seedling production and planting of one million seedlings per year (1000 seedlings per acre on 1000 acres) is currently anticipated.

WOOD CHIPPING

Only one wood chipping plant, Maui Hardwoods, Inc. is operating in Hawaii now. Maui Hardwoods, Inc. sells wood chips to Pioneer Sugar Company's mill for use as supplemental fuel to bagasse in its boilers. Another wood chipping operation, Capital Woodchip Company on the Big Island, was operating until a recent fire forced it to close. The existence of the two plants places Hawaii in an advantageous position. It means that the hardware, technology, and knowledge of wood chip operations will be available when energy tree farms are harvested.

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AQUACULTURE IN HAWAII

The Promise Of A Thriving Industry

Hawaii is an excellent location for aquaculture. The state has warm year-round temperatures, sufficient land for fresh, brackish, and salt water aquaculture, and a tradition of fish farming that extends back to the ancient Hawaiians.

Preliminary evaluations on developing aquaculture farms have been encouraging, but one of the most compelling arguments for continuing the research is the success of the fresh water prawn program. Another success in the area of aquaculture is the Systems Culture operation at the Kahuku Seafood Plantation.

Systems Culture is currently undergoing an expansion, and expects to be producing 77 metric tons of shellfish, or 1.4 million animals, per month. The product will be primarily oysters, but clams and abalone will be secondary products, which could become major products in the future. By March or April of 1981 refurbishment of the present system will be complete.

The new system will consist of 10 acres of available ponds producing 7.5 million gallons of phytoplankton per day to be used as feed for the shellfish. The marketable animals will be produced in 12 trenches and the oyster seeds, each approximately 2.4 mm, will be contained in 25 nursery boxes.

The water pumping requirements for Systems Culture will amount to 24,000 gallons per minute. Because of the large amount of energy used in pumping, Systems Culture is cooperating with HNEI and the UHM Department of Meteorology in their efforts to develop wind energy conversion systems. The understanding is that any viable machines could be usd to provide power or pumping for Systems Culture. Currently a small wind-powered water pumping machine, a wind-powered nitrogen fertilizer project, a Dunlite machine, and an instrumented tower are up at the Kahuku Seafood Plantation. More are being planned or considered for the future.

The State Department of Planning and Economic Development is studying various aquaculture research projects and experimental farms. Several options appear promising now, but one of the most interesting is aquaculture in combination with ocean thermal energy conversion (OTEC) systems. Deep cold water is pumped to the surface during OTEC operations and testings, and this water may be ideal for the cultivation of cold-water animals and plants. The OTEC Seacoast Test Center is designed with an area specified for aquaculture research.

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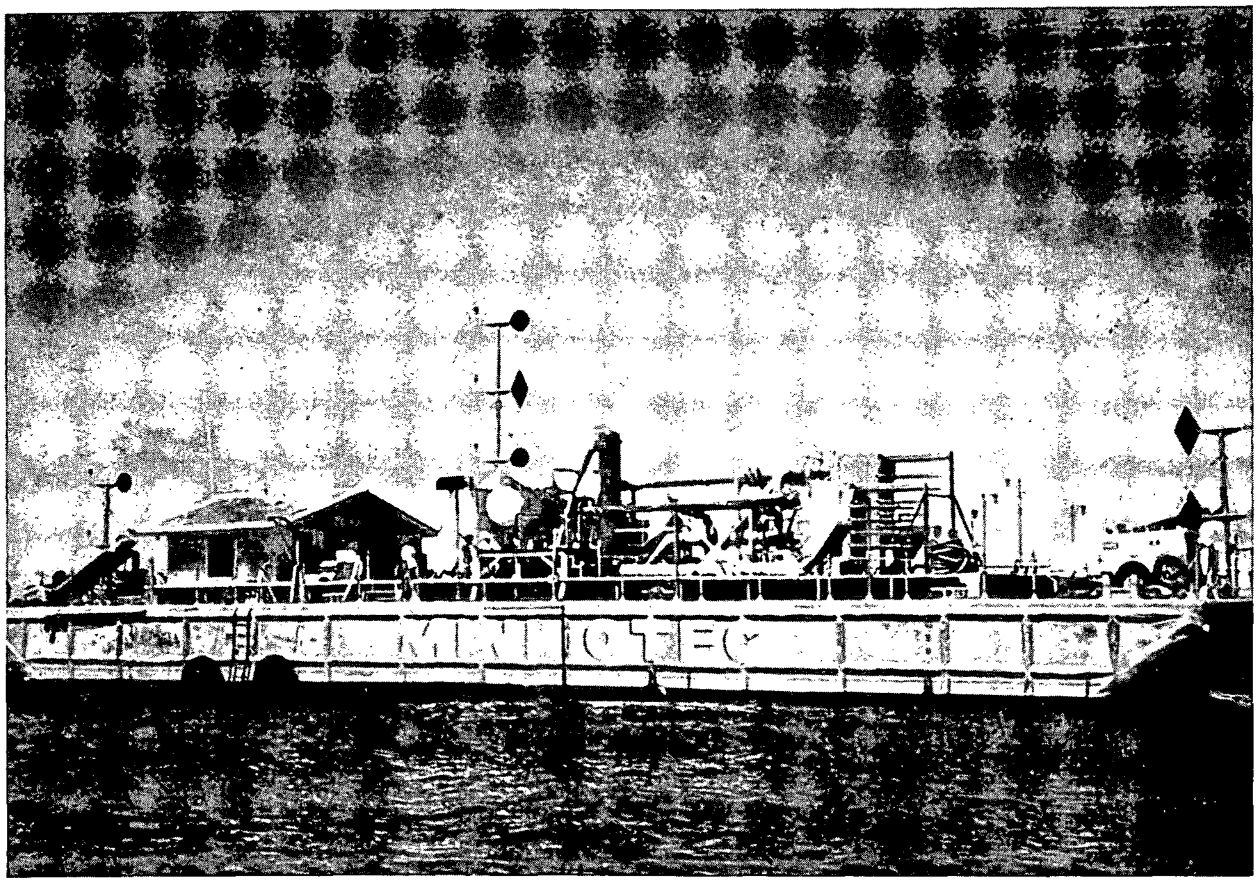
MINI OTEC

The World's First Successful Floating Closed-Cycle OTEC



Mini-OTEC was the first floating closed-cycle ocean thermal energy conversion (OTEC) system to operate successfully. In August of 1979, upon completion of three months of operation, it proved that net electricity generation is possible from an OTEC plant.

In a closed-cycle system such as Mini-OTEC, a working fluid, ammonia, is heated in an evaporator by warm ocean surface waters. The ammonia, chosen because of its low boiling point, turns to vapor and drives a turbine generator to produce electricity. From the turbine, the vapor passes to a condenser where it is cooled and returned to the boiler as a liquid. Cold ocean water is pumped up from about two thousand feet and circulated through the condenser to cool and thus convert ammonia vapor back to liquid to begin the cycle again.

Mini-OTEC was a remarkable achievement not only because it proved the practicality of the OTEC principle, but because it required no federal money and went from concept to completion in only fourteen months. It was also selected by the National Society of Professional Engineers as one of the outstanding engineering achievements of 1979.

Lockheed Missiles and Space Corporation designed and integrated the Mini-OTEC, while Dillingham modified and outfitted a navy barge on loan from the U.S. Department of Energy, and deployed the cold water pipe and barge at a site one mile off Ke-ahole Point, Hawaii. The state funded the barge modification and outfitting as well as the half-mile long 24 inch diameter polyethylene pipe used to bring up cold water. Hawaii County and Alfa-Laval Thermal, Inc. were additional participants in the project.

About fifty kilowatts of electricity were generated by Mini-OTEC; approximately 35 were used for the cold water and ammonia pumps, leaving about 15 kilowatts for other uses. Because it was only a demonstration project, no electricity was sent to shore.

Decommissioned after successfully demonstrating the practicality of the closed-cycle concept, Mini-OTEC awaits a second deployment, financed this time by the DOE, Lockheed, and other participants. This second deployment will be primarily a test of biofouling countermeasures, but aquaculture experiments may also take place.

Biofouling is the growth of micro-organisms that act as undesirable insulators on heat exchangers, and reduce the efficiency of OTEC operations. Another obstacle to efficiency is corrosion, a result of contact with sea water. Tests on countermeasures for both of these problems are ongoing at the Seacoast Test Facility and on OTEC-1, and will be part of the Mini-OTEC second deployment.

The first deployment of Mini-OTEC was a tribute to the dedication of the researchers, scientists, and technicians in the state.

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HYDROELECTRIC SYSTEMS FOR HAWAII

Using Mountain Streams To Produce Electricity

Hydroelectric plants in Hawaii are run-of-river plants; they use available stream flows without dams. Run-of-river plants without storage use the water directly as it comes through the stream to turn a turbine and generator to produce electricity. Most run-of-river plants in Hawaii are capable of maintaining a base electrical load throughout the year because there is always at least a minimum flow of water.

Hydroelectric plants, however, can come equipped with storage and one of the most promising such systems for Hawaii appears to be pumped storage. A pumped-storage plant consists essentially of an upper and lower pond. During times of peak load, water is allowed to flow from the upper pond to the hydro plant, generate electricity, and go finally to the lower pond. During non-peak times, water is pumped from the lower pond to the upper, so it will be available when needed again. Wind-powered pumped-storage plants in which wind provides the energy needed for pumping are practical in strong wind regimes like Hawaii, and are being planned now.

Even though the hydroelectric potential in Hawaii is small compared to that of wind, direct solar, or geothermal energy, there are definite advantages to hydro-power for Hawaii. Hydro-plants have a minimal effect on the environment, have low operating and maintenance costs, and are capable of starting up quickly.

Spread-out across the islands of Hawaii, Maui, and Kauai are 19 small run-of-river hydroelectric plants. The Big Island (Hawaii) has nine hydroelectric plants with a combined rated capacity of 5435 kilowatts. Maui's three hydro-plants can produce 7099 kilowatts, while the eight plants on Kauai are capable of producing 7900 kilowatts. Installed capacity for the state then is 20,434 kilowatts.

The sugar companies and the utilities are interested in increasing the amount of electricity produced by hydro-power, and are studying, planning, or installing larger and more efficient systems. Olokele Sugar Company in Kauai, for example, has announced plans to install a 1.25 megawatt hydroelectric unit at the mill. Expected to be completed by December 1981, the plant will sell six million kilowatt hours a year to Kauai Electric Company. Total plant cost is $1 million, all private money.

The State Department of Planning and Ecnomic Development is funding two separate hydroelectric studies to measure the state's hydro potential, and to make recommendations and suggestions for increasing the productivity of hydroelectric systems. At least five percent of the electricity used in the state could be produced through this resource.

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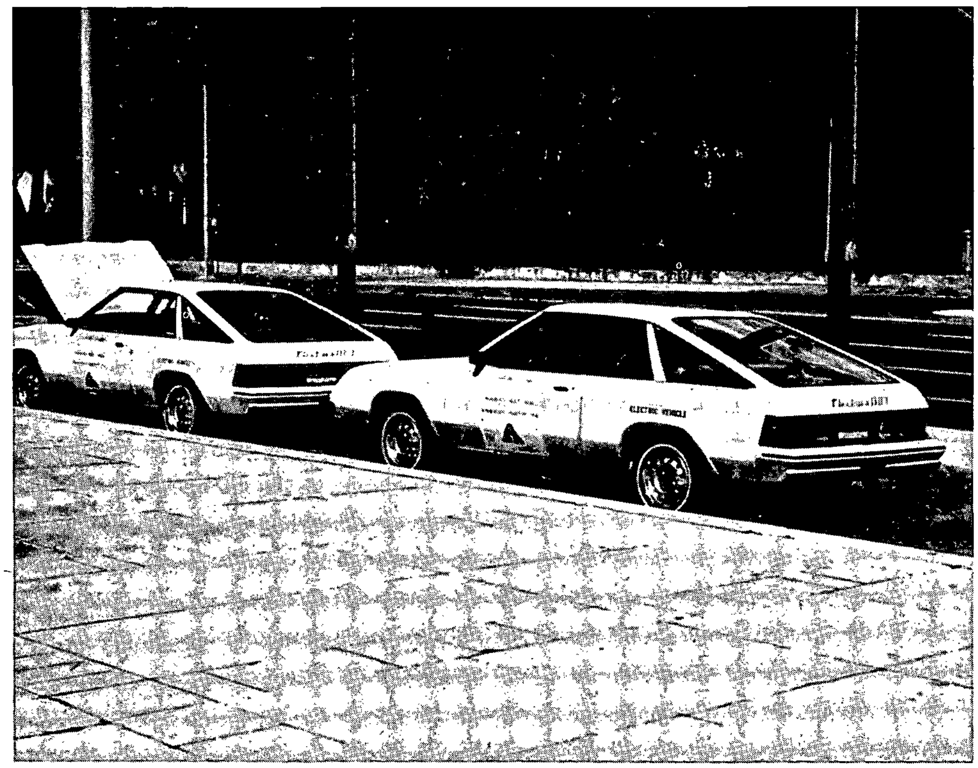
THE ELECTRIC VEHICLE

The University Is Conducting A Demonstration Program Using 15 Vehicles



As part of a national effort to reduce our reliance on petroleum, the Hawaii Natural Energy Institute (HNEI) of the University of Hawaii at Manoa (UHM) is conducting an electric vehicle demonstration project. The United States Department of Energy has awarded a grant to purchase and operate fifteen vehicles on selected Oahu routes for four years. The vehicles, purchased from Jet Industries of Austin, Texas, are five converted Dodge Omni sedans, five converted Ford Courier pick-up trucks, and five converted Dodge Passenger Vans. They are being integrated into the UHM Transportation Services' fleet and operated and maintained by the Transportation Services. Drivers must be certified through completion of a special electric vehicle driver training program before operating the cars, trucks, or vans.

Including one year for program planning, driver and mechanic training, and preparation of facilities, the total project length will be four years. When the demonstration is over, the vehicles will remain the property of the university, thus providing much needed reinforcement to the UHM fleet. Operation and maintenance procedures will be evaluated continually, and in this way, UHM students will gain valuable knowledge of these vehicles.

The project, with a total budget of $585,911, is designed primarily to provide public visibility for the electric vehicles and to demonstrate their value as replacements for vehicles operated by gasoline-powered internal combustion engines. They are not meant to replace all gasoline burning cars, but can be used for specific tasks in specific situations. Central Oahu, with short average driving distances and generally flat terrain, is the ideal site for a demonstration of these vehicles. Most of the vehicles are now driven an average of 20-30 miles a day, but under optimum circumstances, they could go as far as 80-85 miles before needing a recharge. Charging systems are being installed at the UHM motor pool, and at Holmes Hall.

The primary advantage of an electric vehicle is that it does not use gasoline. The electricity needed to charge its batteries can be obtained from many natural energy resources and thus is easier to produce than liquid fuel. Use of the electric vehicle, however, also provides many other advantages:

- Electric vehicles do not emit hydrocarbon, carbon monoxide, and nitrogen pollutants as do gasoline-powered vehicles.
- Electric vehicles are silent, causing no noise pollution.
- Electric vehicles use little or no energy when stopped in traffic.
- Electric vehicles need less service because of lower vibration, fewer moving parts, and simpler design.

Facts about the HNEI/UHM electric vehicles:

- Maximum speed is 45-55 mph
- Accelerates to 30 mph in less than 13 seconds
- Sedan and pickup are powered by 20, 6 volt, lead-acid batteries
- Van is powered by 24, 6 volt, lead-acid batteries
- Batteries good for 10-20,000 miles
- Maximum range between charges is 40-50 miles
- 100% charge in 8 hours

Hawaii's energy future will be made brighter through the use of electric vehicles; they can be powered by electricity from our abundant natural energy resources—wind, geothermal, OTEC, biomass, and direct solar.

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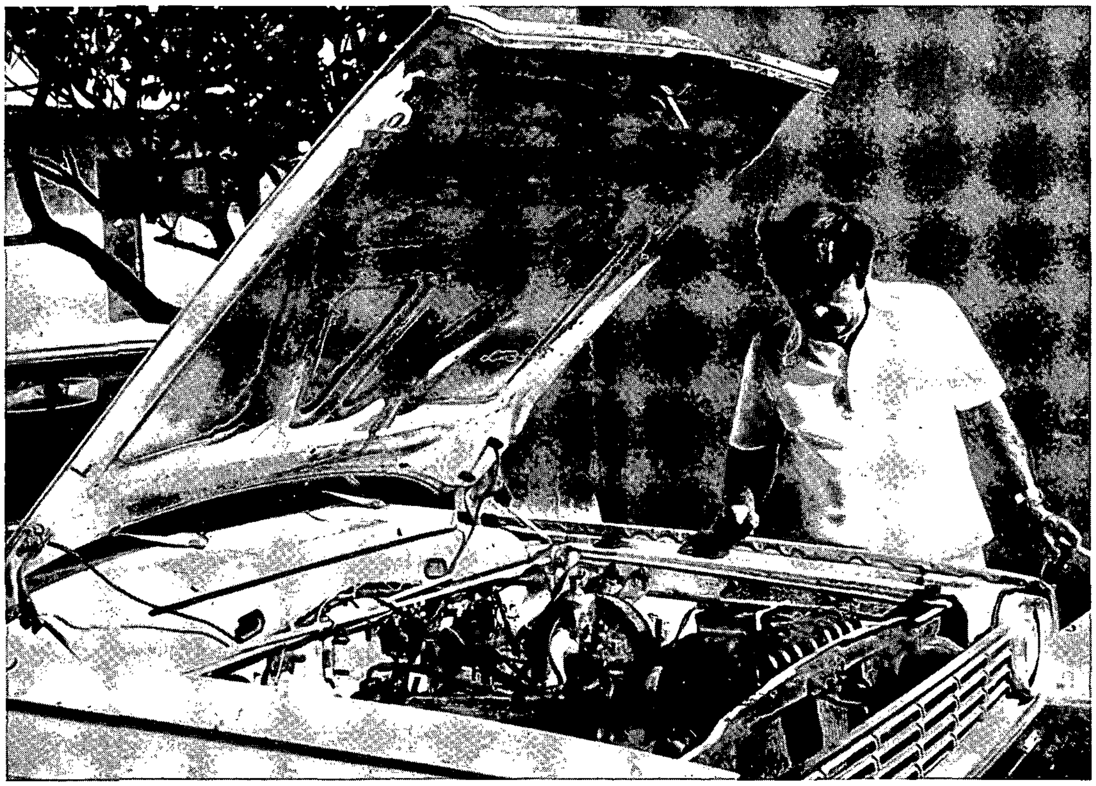
SYNTHETIC FUELS

To Provide The Liquid Component Of Hawaii's Energy Needs



Since 1979, gasohol, a mixture of 10 percent ethanol to 90 percent gasoline, has been available on a limited basis in Hawaii. The reason gasohol is not used even more widely is that ethanol must be imported. Since 1978, however, a study of obtaining ethanol from sugar cane molasses has been ongoing. The study's focus is not simply on producing ethanol, because these processes are well known, but on recovering valuable stillage by-products as economically as possible. These by-products, animal feed and fertilizer, could be sold to bring down the cost of ethanol. Pacific Resources, Inc. (PRI) and C. Brewer and Company, Ltd. have both been developing plans to build large ethanol plants.

A Department of Energy award of more than $900,000 for a synthetic fuels feasibility study recently went to C. Brewer to perform the process design and definitive engineering work required for a plant to produce ethanol from molasses. Following the feasibility study, a plant may be built at C. Brewer's Hilo Coast Processing Company on the Island of Hawaii.

Commercial production of ethanol, meanwhile, is becoming a reality in Hawaii. An unused rum plant on Maui, owned by Alexander and Baldwin Company, has been leased to Maui Distillers for the purpose of producing alcoholic beverages. Renovation of the plant will begin soon, so that alcohol will be produced in early 1981. According to the contract, Maui Distillers will produce 10 to 15 thousand gallons a month of anhydrous alcohol, a small amount of which Alexander and Baldwin will use as fuel.

For the past few years, Del Monte Corporation has been producing ethanol from pineapple juice and shipping it to the mainland for the manufacture of vinegar. Now the Dole Company has begun producing ethanol also, and this product is used for fuel.

Some experiments on using only ethanol or alcohol to power motor vehicles are ongoing in Hawaii, and an instructor of auto mechanics at Maui Community College, Mr. Richard Miyashiro, has converted his own car to run on either pure alcohol, pure gasoline, or a mixture of both. The conversion was simple and consisted of installing a new carburetor and making adjustments in the timing mechanism. In a joint project of HNEI, Maui County, and PRI, Mr. Miyashiro is converting an additional vehicle and performing 5000 mile road and dynamometer tests one each of the cars. PRI is supplying the ethanol.

While in the past, studies of alternative liquid fuels for use in Hawaii have concentrated on ethanol from molasses, different methods with different feedstocks and end products now are being evaluated. The total production of molasses in Hawaii, about 300,000 tons per year, could provide only 6 percent of the gasoline consumed in the state. More is needed.

Because of the need, PRI, the Institute of Gas Technology (IGT), and HNEI are involved in a 15 month study of the feasibility of commercial production of liquid or gaseous fuels from cellulosic biomass materials. The essence of the process is simultaneous extraction of oil and gaseous products from solid carbonaceous feedstocks.

The process being studied, called HYFLEX™ has been developed by IGT. It involves hydropyrolysis, a breaking apart of complex molecules into simpler units by the use of heat, which takes place in an atmosphere of hydrogen. In the HYFLEX™ process, carbon and water react with heat to produce carbon dioxide and hydrogen. The hydrogen then combines with carbon to produce fuel. Gasoline can be produced in this way using eucalyptus, giant koa haole, bagasse, or pineapple plants as the feedstock. By controlling reaction time and temperature, the products produced can be varied according to feedstock availability and market demand. This method has been commercially successful with coal on the mainland, and in theory any carbonaceous material will work. The U.S. DOE has awarded slightly more than $330,000 to the PRI team for this project.

Oil also can be produced from a strain of algae under certain cultivation practices and this is being demonstrated through a project entitled "RD&D of Algal Production Raceway Systems for the Production of Hydrocarbons." The initial study indicated that high yields of oil, approximately 150 barrels per acre per year, could be produced, and the two-year follow-up now underway, consists of system design, prototype construction, demonstration and market assessments.

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