Council received general information regarding wind electric generation, along with specific data describing the Cameron Ridge Wind Power Plant Project. This project is to be a joint venture of NCPA and the Wind Energy Company (WEC).

PROJECT DATA SUMMARY

Cost:	$93,400,000 (includes $10,000,000 payment to WEC for wind sites), to be financed by NCPA/cities.
Size:	40,000 kw (40 MW).
Location:	Cameron Ridge, Kern County, California (1,860 acres leased by WEC). Excellent wind site.
Description:	80-500 kw wind turbine generators.
Timetable:	Commercial operation by 1983-'84.
Benefits:	50% of net (approx.).
Utilization by Lodi	3,000 kw in 1995* (7.5% participation).
Lodi phase 2 Liability:	$165,000 (approx.).

Continued May 19, 1982

Project Evaluation: Marginal investment under current terms and at present interest rates. Financial success too dependent upon profitable layoff (sale) of early year energy.

PARTICIPATION IN WIND 1 ELECTRIC GENERATION PROJECT (NCPA) REJECTED

Following discussion and questions being directed to Utility Director Curry, on motion of Council Member Olson, Pinkerton second, Council determined not to enter into the NCPA Phase 2 Agreement covering the Wind 1 (Cameron Ridge Power) Project at this time.

COUNCIL COMMUNICATION

TO: THE CITY COUNCIL FROM: THE CITY MANAGER'S OFFICE	DATE May 7, 1982	NO.

SUBJECT: WIND 1 ELECTRIC GENERATION PROJECT

RECOMMENDED ACTION: A City Council decision that Lodi not enter into an NCPA Phase 2 Agreement covering the Wind 1 (Cameron Ridge Power Plant) Project, at this time. Though significant long-term benefits could result from participation in a generation project at this excellent wind site, current terms and conditions make the project a 'marginal' investment. Phase 2 participation at an appropriate level (3,000 kw, 7½%), would require the assumption by Lodi of a $165,000 cost liability for project design, development and further analysis.

BACKGROUND INFORMATION: Council has received general information regarding wind electric generation, along with specific data describing the Cameron Ridge Wind Power Plant Project. This project is to be a joint venture of NCPA and the Wind Energy Company (WEC).

PROJECT DATA SUMMARY

Cost:	$93,400,000 (includes $10,000,000 payment to WEC for wind sites), to be financed by NCPA/ cities.
Size:	40,000 kw (40 MW).
Location:	Cameron Ridge, Kern County, California (1,860 acres leased by WEC). Excellent wind site.
Description:	80-500 kw wind turbine generators.
Timetable:	Commercial operation by 1983-'84.
Benefits:	50% of net (approx.).
Utilization by Lodi:	3,000 kw in 1995* (7.5% participation).
Lodi Phase 2 Liability:	$165,000 (approx.).
Project Evaluation:	Marginal investment under current terms and at present interest rates. Financial success too dependent upon profitable layoff (sale) of early year energy.

David K. Curry
Utility Director

* Future energy requirements depend on load growth, a quantity which is somewhat uncertain, with high interest rates and the passage of Measure 'A' (growth initiative).

(follow-up)

May 26, 1982

Gail Sipple
Northern California Power Agency
8421 Auburn Blvd.
Suite 160
Citrus Heights, CA 95610

Dear Gail:

Please be advised that the Lodi City Council, in action taken at a regular meeting held May 19, 1982, decided not to enter into the NCPA Phase 2 Agreement covering the Wind 1 (Cameron Ridge Power Plant) Project at this time.

Should you have any questions regarding this action, please do not hesitate to call this office.

Very truly yours,

Alice M. Reimche
City Clerk

AR:dg

cc: David Curry
Utility Director

WIND 1 AND OTHER PROJECT DATA

For the past two years, wind speed and direction measurements have been taken at nearby anemometer stations operated by both Wind Energy Company (WEC) and the California Energy Commission (CEC). There are now seven anemometer stations operating in the area*, with more than six months of continuous data on most of them.

NCPA has reviewed the WEC and CEC data and has concluded that the proposed site does, as suggested by WEC, constitute a highly viable wind energy project location. Average annual wind energy capability measured at the site exceeds 700 watts per square meters (W/M^2). This compares to 400 W/M^2 for the highly sought after San Gorgonio Pass, 550 W/M^2 for Pacific Gas & Electric Company's (PG&E) Solano site, where their 2.5 MW wind turbine is nearing completion and where additional development is planned, and 600 W/M^2 for the Hawaiian Electric Company's $290 million 80 MW Kahuku Wind Energy Project. The Kahuku project is a joint development with Windfarms, Ltd., and is scheduled for full operation by 1985.

* Cameron Ridge

4/26/82

California Windpower

PGandE has announced completion of a 2.5 Mw Boeing wind machine northeast of San Francisco. PGandE and Boeing expect to spin the rotor in early April.

Windfarms Ltd. of San Francisco has announced that the 350 Mw windfarm it plans to erect for PGandE in Solano County Ca., will be deferred at least 6 months. Delays in preparation of the EIS and the expected lowering of "avoided cost" (the price PGandE would pay for the power) were cited as the reasons.

Southern California Edison Co. has announced 4 agreements for wind power. A letter of intent with First National Capital calls for 60 windmills with a total output of 30 Mw at San Gorgonio Pass. Ten windmills with a combined capacity of 5 Mw have been installed in the Tehachapi Mountains by Ridgeline Windfarm, and are expected to begin generating electricity in April or May. A third contract with American Wind Energy calls for 80 windmills of 50 Kw each. The fourth contract with Oak Creek Energy Systems is for 5 Mw worth of windmills near Tehachapi.
(The Energy Daily, 3/30/82)

San Gorgonio Wind Resource Study

The BLM and Riverside County have prepared a draft EIS/EIR on the proposed development of wind energy resources in the San Gorgonio Pass near Palm Springs, Ca. Comments will be accepted until May 2, 1982.
(Federal Register, 3/19/82)

Solano Ca., Wind Turbines

Windfarms Lt., of San Francisco, has filed an application with FERC for Commission Certification of Qualifying Status of a Small Power Production Facility.

Windfarms is proposing to construct 21 wind turbines, all within a mile of one another, in Solano Co., Ca. The generators will have nameplate capacities of 2.5 and 5.0 Mw each. The total projected capacity of the installation is 92.5 Mw.
(Federal Register, 3/15/82)

Loans for Wind Energy and Small Hydro

DOE cancelled its March 9, 1982 public hearings on loans for wind energy systems and small hydro project, due to lack of public interest in making oral presentations. Written comments on the proposed rulemaking are due April 19, 1982.
(Federal Register, 3/3/82, p. 9017)

Wind Turbine Handbook

DOE's Pacific Northwest Laboratory has prepared a handbook that explains the meteorological aspects of siting large wind turbines. Copies of the handbook (PNL-2522) are available from NTIS.
(Electric Light and Power, 3/82)

Fairfield Wind Turbine

The City of Fairfield Ca., began operating a wind turbine May, 1981. Since that time, it has produced 33,000 Kwh of power and has resulted in over $2,300 in electricity sales to PGandE. The City expects the machine to produce an annual revenue of $5,500.
(California Energy Commission News & Comments, 2/82)

BLM Rights-of-Way for Wind Generators

The California BLM has developed procedures for granting rights-of-way for competing applications for wind-power generating facilities on public lands. Comments on these procedures are due March 26, 1982.
(Federal Register, 2/25/82, p. 8253)

Bureau of Reclamation Windmill

A 2½ Mw wind machine built by Boeing in Wyoming is in a shutdown mode due to lack of funds. The project was built under contract to the US Bureau of Reclamation, which does not presently have the funds for the testing necessary before the government will accept the machine. The USBR is considering three options: garnering more federal funds, turning the project over to the state of Wyoming, or making some arrangement with the private sector.

One of the unique features of this project is that it would be tied into the USBR's hydroelectric grid. Thus power generated by the wind machine would decrease the amount of electricity demanded from hydro facilities, resulting in a form of energy storage.
(The Energy Daily, 2/23/82)

PGandE Windfarm

PGandE and Windfarms Ltd. have negotiated a contract for a 350 Mw windfarm in Solano Co. Ca. The California Department of Water Resources has signed a separate contract allowing it to purchase a portion of the off-peak power.

Windfarms Ltd. will finance, build, operate and maintain the project. Construction is scheduled to start in late 1982.
(Solar Energy Digest, 2/82)

Loans for Wind and Small Hydro Projects

DOE is issuing proposed rules to establish procedures for making and administering direct loans for the development of wind energy systems and small hydroelectric power projects. (However DOE has recommended that Congress appropriate no funds for these programs, the proposed rulemaking is only for purposes of complying with PURPA and the Wind Act.)
(Federal Register, 2/16/82)

WIND ENERGY PROGRESS AT PGandE

Presented at

UMC Wind and Solar Energy Technology Conference

April 5-7, 1982

Kansas City, Missouri

Presented by

Michael V. Russo

Generation Planning Department
Pacific Gas and Electric Company
77 Beale Street
San Francisco, CA 94106

WIND ENERGY PROGRESS AT PGandE

Michael V. Russo
Generation Planning Department
Pacific Gas and Electric Company
77 Beale Street
San Francisco, CA 94106

ABSTRACT

Pacific Gas and Electric Company has been actively involved with the renaissance of wind energy in the United States. PGandE is currently dependent on fossil fuels for 45% of its generation mix, but has been blessed with a service territory that has an excellent wind resource. These two ingredients have resulted in an increasingly successful wind energy program.

Following promising results from a 1979 California Energy Commission-PGandE study, the Company began a sixteen-site meteorological monitoring project in 1980. Data reduction has confirmed that winds of commercial quality exist in several large areas near San Francisco.

Using in part this meteorological data, the Company sited its 2.5 MW Boeing Mod-2 in Solano County, California. The performance of this turbine, scheduled to begin commercial operation in May 1982, will be closely monitored. We hope to gain insights into such factors as the effect of variable winds during operation, electrical integration into the PGandE grid, and the potential of the site for a major expansion of wind capacity.

Our new resource plan calls for a portion of capacity from 382.5 MW of wind energy projects by 1992, including the PGandE unit, now under construction. As a utility whose peak load is greater than 15,000 MW, we have the ability to accept substantial amounts of wind power.

Studies to evaluate the firm capacity of wind energy continue. Empirical results from data collection in two study areas indicate that the potential of both sites combined may be greater than each one taken separately. Economic studies have shown that commercialization of large turbines may depend on the Mod-5 being brought to the market. Economic assessment is an aid to utilities even if they take no equity interest in these projects.

Negotiations are currently under way with various private wind energy companies for projects that could more than double the total installed megawatts of wind energy planned to be on line by 1992. Two companies already have installed megawatt clusters of turbines and are connected to our grid for electric sales in the near future. PGandE is anxious to assist third parties in developing their projects. We believe that wind energy has a

bright future in our service area, and are planning for its implementation.

PGandE's RESOURCE PLANNING PROCESS

Goals

PGandE's resource plans are designed with several utility objectives in mind. The foremost of these is to provide reliable service at the lowest practicable cost to the ratepayer. We aim to accomplish this goal while avoiding unreasonable risk for stock and bondholders and operating in a manner consistent with current regulatory standards and practices, including environmental control. Diversification of generating facilities away from oil-fired plants is sought as a means of increasing efficiency and security against fossil fuel price fluctuation.

Planning Input

Important input to our electric supply plan, along with refined techniques to project system demand, are the elements by which we judge proposed additions to our electric resources. Emphasis is placed on flexibility and diversity -- both of type of resource and the role that it can best play in meeting our needs. The Company develops capacity requirements for a chosen level of reliability. An acceptable quantitative definition of that interval might be the commonly used industry standard of a loss of load probability (LOLP) index of one day in 10 years. This LOLP index is used to determine planned capacity reserve margins. Conceptually, this means that sufficient sources of generating capacity are expected to be available to serve customer load at all times except for one peak-period day in 10 years. With PGandE's current resource mix this corresponds roughly to about a 15 to 17 percent reserve margin or risk of loss of the systems two largest units.

Important also is the ability of the Company to displace older inefficient units with newer units. One alternative is to build new base load plants and back off aging oil-fired units, some of which have been operating since 1948. Another alternative is to reduce the usage of fuel oil and gas in existing plants. This is where wind energy is most advantageous. As a capacity resource, it is not dispatchable, but as an oil-reducer it has great promise. If wind can be economically justified in this way, it makes sense for us to encourage its implementation by third parties.

Wind Energy in the Resource Plan

Our current resource plan includes a portion of the 380 MW of wind energy capacity from which PGandE will be purchasing power. This supplements our 2.5 MW Boeing unit, soon to be completed, for a total of 382.5 MW. The 380 MW in purchases is the sum of

our contracts with U.S. Windpower and Windfarms Ltd. The latter, a 350 MW wind power sales agreement, is the largest of its kind to date. The 382.5 MW total will probably be expanded as we sign contracts with some of the more than two dozen private parties with which we are actively negotiating. For the purposes of meeting loads, we use 20% of the megawatts installed at a given time, so that our resource plan shows 77 MW of wind energy by 1992. This figure will change in accordance with the inclusion of other wind projects and/or operating experience.

THE CALIFORNIA REGULATORY ENVIRONMENT

California Energy Commission

The California Energy Commission has played a key role in the implementation of alternative energy in California. They drafted and carried through the state legislature key laws which have resulted in sizeable tax credits and favorable depreciation allowances. These have given great impetus to the wind industry in California. They currently operate an anemometer loan program wherein potential on-site users of wind energy can borrow this instrumentation to evaluate their wind resource. Other programs include a statewide wind resource assessment and ongoing information dissemination.

California Public Utilities Commission

The California Public Utilities Commission has as one of its major responsibilities overseeing utilities providing electricity to the state. The CPUC sets electric rates and determines the allowed rate of return on equity utilities should be granted. Use of "preferred" technologies such as hydroelectric, geothermal, wind and cogeneration can result in a higher allowed return on equity because the Commission is very interested in seeing their implementation. The CPUC also has the responsibility of approving some non-standard contracts for power purchase, and at the time of this writing, was reviewing the PGandE-US Windpower contract.

The CPUC also decides whether the Standard Offer Contracts themselves are acceptable for use by California utilities. In a recent decision, Order Instituting Rulemaking #2, the Commission ordered that utilities offer several different contracts, some featuring a fixed price and/or capacity payments based on 100% of as-delivered capacity[1].

---

[1] Loosely speaking, as-delivered capacity refers to value of this instantaneous capacity in reducing the chance of a shortage.

The net result of California's regulatory environment has been to provide incentives for utilities to look at new technologies, such as wind energy, with more than a passing glance.

PGandE ACTIVITIES

Meteorological Monitoring Program

In 1979, the Company completed a study done cooperatively with the CEC to determine the feasibility of wind energy in two areas of our service territory (1). Based on the favorable results of this study, PGandE embarked on a broad data collection study in the spring of 1980.

We concentrated on two study areas in Solano County and the Altamont Pass region of Alameda County. In each area, eight towers were sized, equipped, and operated as follows:

Number of Towers	Height (ft)	Measurement Level Heights (ft)
5	30	30
2	100	30, 100
1	300	30, 100, 200, 300

Rohn towers were used, with Teledyne Geotech sensors and digital recorders. The equipment samples every two seconds and stores, on a cassette tape, speed and direction means and filtered variances. In September 1981, a full year of data collection was completed at all sixteen sites. Results indicate that the winds are strongest near the time of summer peak loads. For the two areas, we have estimated annual capacity factors for each of the sites, using a computer simulation that translates hourly wind speeds into output using a Boeing Mod-2 power curve. For 1981, using 30-foot wind speeds, the Altamont sites averaged 34%, the Solano sites, 36%. The relationship between simulated output at the sites and peak loads will be discussed below.

Solano Wind Turbine Project

Based on the results of the PGandE/CEC study and on interest in a new technology that was beginning to show excellent potential for utility electric generation, the Company began siting studies for a large turbine (2). One candidate site was chosen in each of the Solano and Altamont areas, and further studies were conducted. Among these were impacts of visibility and possible encroachment by incompatible land uses, such as housing. Others included the availability of transmission interconnection as well as availability of the site itself for purchase. Computer simu-

lation of measured wind speeds was used to judge the match of high winds to our system peaks. The Solano site was chosen based on these considerations, which were the deciding factors, since both the Solano and Altamont sites had annual winds averaging 18 mph.

Following a competitive bidding process, a Boeing Mod-2 machine was selected for the project. Construction began in June 1981, and the unit is scheduled to begin commercial operation in May 1982. Prior to the completion of the turbine, a 350 foot meteorological tower was erected close by for use in studying the machine's performance. With a consonant program of monitoring, we hope to gain insights into such factors as the effects of variable winds during start-up and shut-down periods and the electrical integration into the PGandE grid.

Empirical Capacity Credit Studies

Analysis to determine answers to some long-range questions about wind energy continues. The issue of capacity credit interests the utilities strongly because it must be addressed regardless of whether the power is produced by it or a third party. By CPUC mandate, payment to third parties will be based on as-delivered capacity, or possible the amount of nameplate capacity that they will contract for. Unfortunately, where we have up to 85 years of USGS hydrological data for some hydroelectric sites, we have little long-term wind speed information anywhere. Since probabilistic studies have difficulty in simulating meteorological conditions on our complex terrain, the summer of 1981 was analyzed in an empirical way, to try to gain an understanding of the relationships among our sixteen meteorological sites.

For our studies, we concentrated on the 50 peak hours of system demand in the summer of 1981. Thus, for a sixteen site system, this resulted in a possible 800 data point study (the actual total was somewhat less, due to down time). Simulated capacity factors, using our a computer model, a Boeing Mod-2 power curve, and measured hourly wind speeds at 30 feet yield noteworthy results.

Figure 1 shows the frequency distribution of the average simulated capacity factor of Mod-2's sited at each of our eight stations in the Altamont Pass area. It is important to note that this average is computed from eight separate capacity factors, rather than the average of eight windspeeds, which would produce incorrect results. Here the wind speeds are not well related to our needs--during 36% of the peak hours, no energy would be produced at any of the eight sites.

At the Solano site, shown in Figure 2, the results are much more encouraging. Here, some power is produced for all but two peak hours. Figure 3 shows the composite averages of 50 hours which

Figure 1

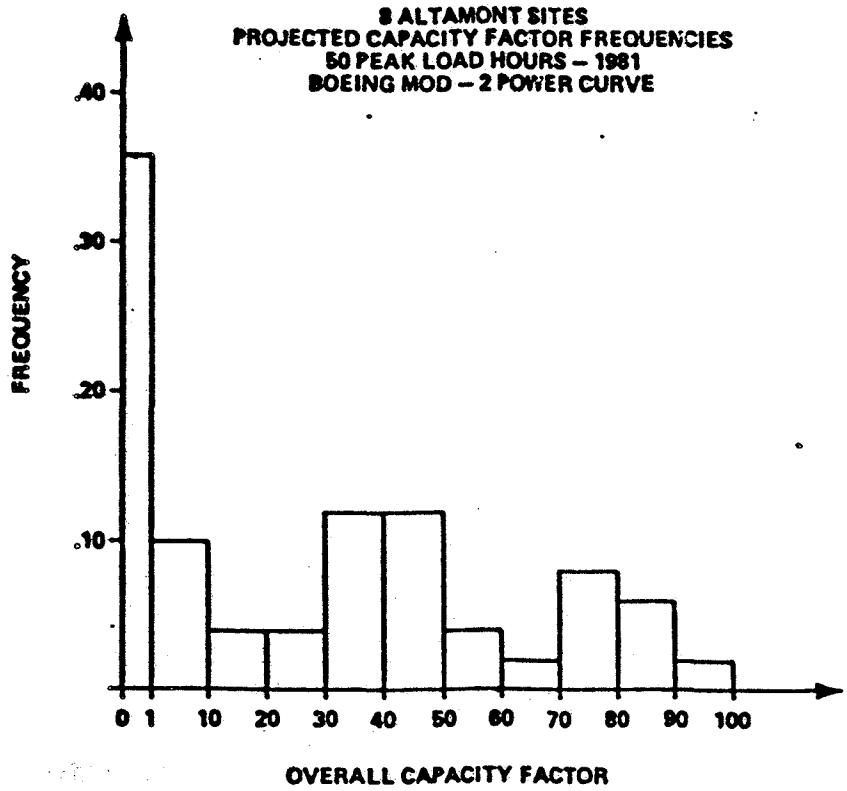


Figure 2

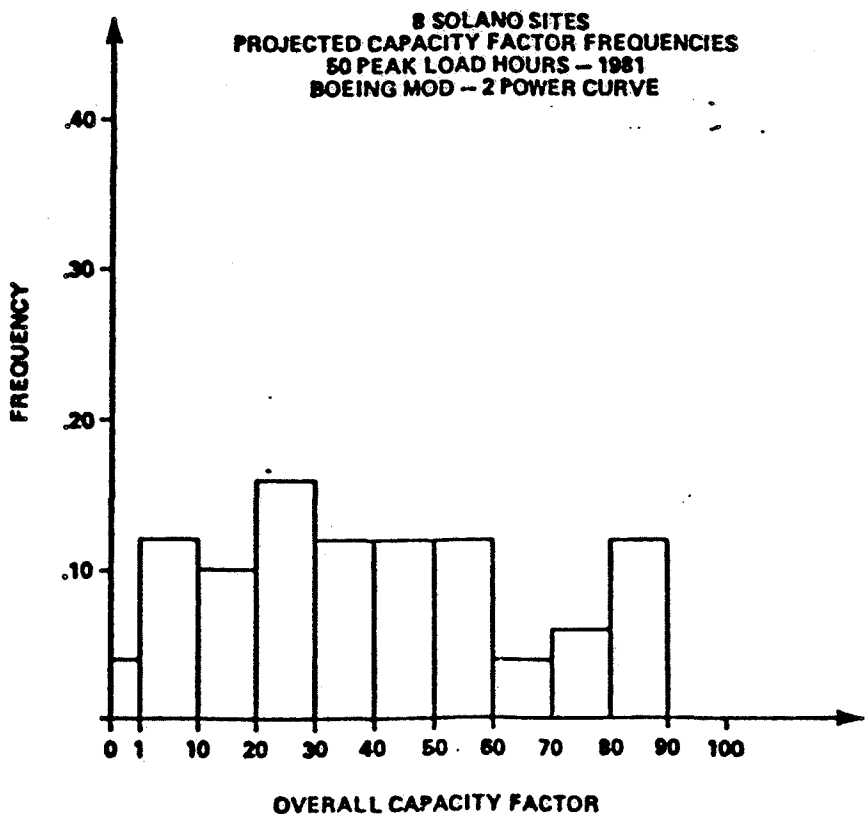
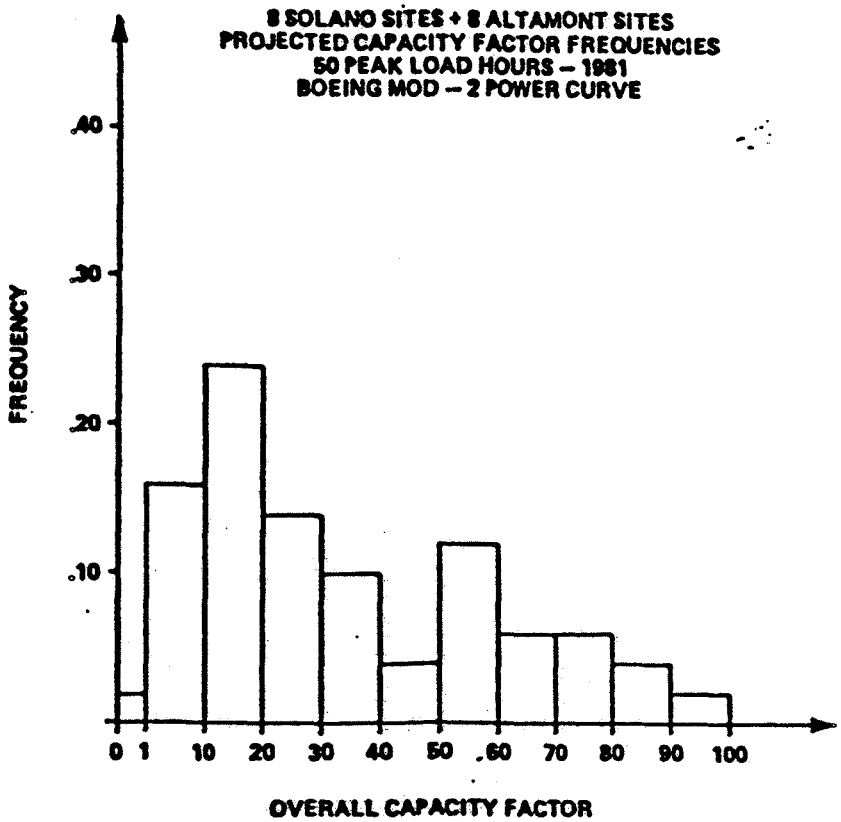


Figure 3



demonstrate that there is some "constructive" correlation, which accounts for only one hour where the combined capacity factor was zero. The correlation coefficient factor between the average capacity factor at the two areas for the 50 hours investigated was .65. Annual correlation factors for the eight sites within the two areas, on an hourly basis, vary from .75 to .98 for the Solano Area and .79 to .97 for the Altamont Area (Averages: Solano, 86.2; Altamont, 89.0). Most of the hours of zero operation at Altamont were balanced by some potential generation in Solano, which accounts for the large frequency in the 0-30% range.

Of course, these results were obtained from only one year of data at the two sites using only 30 foot data. Further evidence from more years and more potential site areas, as well as analysis of the nature of wind shear, will provide greater insight into the value of the resource in our service territory.

Wind Farm Economics

Perhaps the most salient issue is whether development is likely to be dominated by large or small (less than 100 kW) machines or both. For the type of terrain on which the resource exists in our service territory, more MWhr/acre may be produced with larger machines, but this may not prove an important consideration. Strong evidence exists that commercialization of the largest

machines may depend on the Mod-5 being brought to the market. We have completed a comprehensive cost simulation of a 5,000-acre, 94-site wind farm, and the results indicate that an extension of tax credits, and their qualification for utilities may be needed to justify such a venture. Estimates for operation and maintenance show that this is a major expense, especially given a utility's accounting system of fixed charge rates and escalation. The figure for O&M generally used for calculations is 2% of the capital cost, escalating annually. Escalated and levelized, this figure rises to up to 25% of the base case fixed charge rate. A similar study for a field of small turbines would be helpful in determining their value.

In a sense, these studies are not crucial at this time because capital constraints, reluctance to transfer technological risk to the ratepayer, and denial to utilities of certain tax credits all indicate that the Company should encourage private investment in wind energy. But analysis is necessary because it is important for us to have an understanding of basic wind farm economics, both as an aid to contract negotiation and as a tracking mechanism for a new technology.

Third Party Contracts

Given the present situation that America's utilities find themselves in, locating private capital to devote to building generating facilities is a high priority. In this spirit, PGandE encourages power sales projects by third parties who can better bear the risks and receive the benefits of new technology ventures.

Encouraging private investment in wind farms can best be accomplished by entrepreneurs reducing to an acceptable level the risk factors borne by each participant in the venture. The types of risk involved are:

1) Technical Risk - Will the machine work as designed?

2) Resource Risk - Will the wind blow as expected?

3) Price Risk - Will power sales fully compensate investors?

4) Regulatory Risk - Will PURPA prices always be in effect?

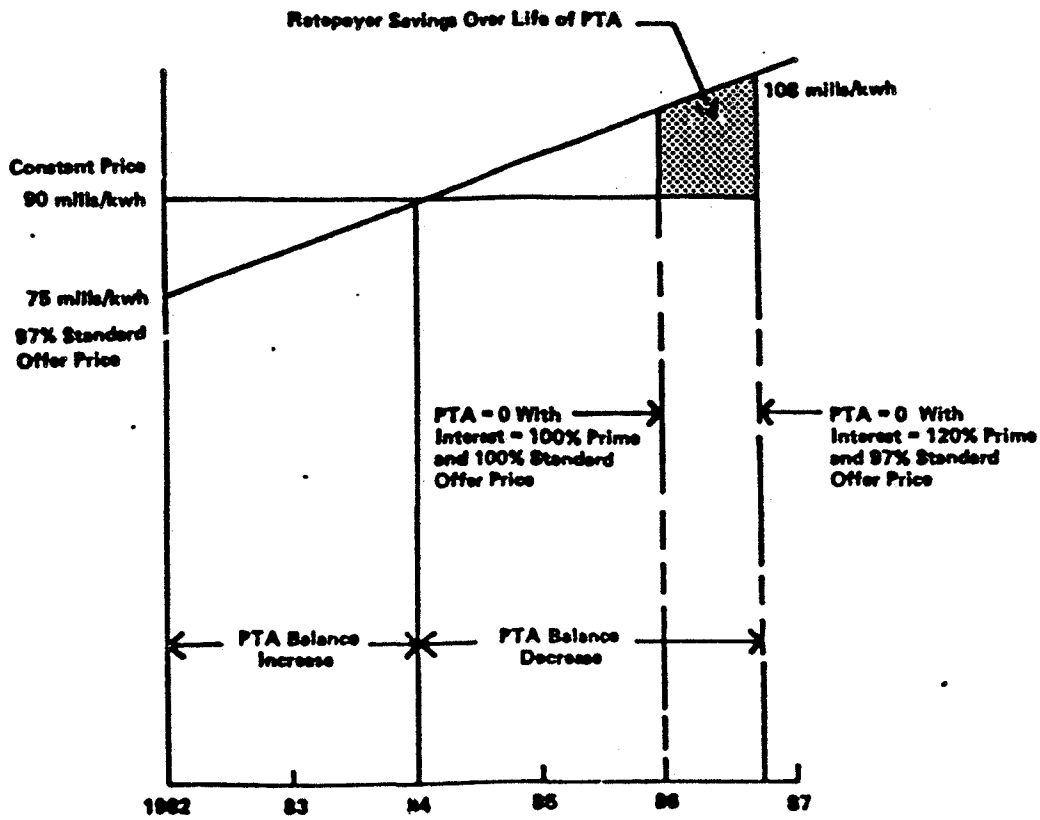
Technical risk can best be minimized through stringent quality control and extensive operating experience. Resource risk can be insured for, as has actually been done by several developers in California. Allocation of the price uncertainties imbedded in an agreement can be shared by all concerned parties--the developer, utility, and its ratepayers. Negotiation can result in the proper apportionment of this risk among the participants, as well as the rewards for accepting it. Regulatory risk can be mitigated by similar, negotiated arrangements.

Since repayment of the note through which a development is financed requires constant payments (in current dollar terms), income assurance is desirable. This situation may be remedied somewhat by a fixed price payment for delivered power in early years, with appropriate compensating contractual provisions followed by compensation to the utility later in the project's life. This was the arrangement negotiated with US Windpower, Inc.

The USW/PGandE contract calls for a fixed price of 9¢ or 10¢/kWh (depending on tax credit legislation) in the early years of the contract. The difference between 97% of our Standard Offer price and the fixed price accrues, with interest, in a tracking account, until payment in excess of the Standard Offer price draws the account down to zero. Following this period, discounts from the Standard Offer of 5% through 2001, and 10% until 2011 occur. Thus, a fixed price for delivered power for the duration of the tracking account has assisted USW in obtaining financing, while the ratepayers are adequately compensated for the risk they shoulder (an internal rate of return of 63% over the life of the contract, using base case assumptions). The rate of return to the ratepayer over the life of the tracking account only, is 46%, as illustrated below.

Figure 4

MECHANICS OF THE U.S. WINDPOWER/PGandE
PAYMENT TRACKING ACCOUNT (PTA)



Fixed price contracts of the type just explained will not replace PGandE's present Standard Offer, but were designed to allow financing of some early projects. Currently, California utilities are changing their Standard Offer in response to a CPUC order, and expect to complete this process soon.

While each third party we have negotiated with has taken their own route towards pursuing their project, certain features common to all have appeared. The importance of initiating utility contact as soon as possible cannot be overemphasized. PGandE may need several months in order to complete lengthy and often complicated interconnection studies, and contract negotiations can often take longer than anticipated.

The magnitude of third party wind activity in our service territory has been extremely gratifying. Aside from U.S. Windpower's 30 MW and Windfarms, Ltd.'s 350 MW projects, and a 2.8 MW installation by Farrell-O'Keefe Properties, we are continuing to talk to over two dozen developers, some of whom are municipalities. These parties would like to sell us power from projects ranging up to 100 MW in several resource areas in our service territory. The CEC has estimated that our two prime wind resource sites, the Solano and Altamont areas, could ultimately yield 1800 MW. While this may be an upper bound, we continue to be optimistic about the future of this renewable source of energy.

REFERENCES

(1) Davis, Earl and Ron L. Nierenberg, Wind Energy Prospecting in Alameda and Solano Counties, May 1980, Pacific Gas and Electric Company, Meteorology Office.

(2) Shikuma, Rae. Siting the First PGandE Wind Turbine Generation, April 1980, Pacific Gas and Electric Company, Siting Department.

NOTE: Source: California Energy Commission

PROGRESS OF WIND DEVELOPMENTS

	1981		1982	
	No. of Turbines Installed	Generation	No. of Turbines Scheduled to be Installed	Generation
Altamont Pass - (Alameda County, 2 projects)	69	4.0 MW	468	28.4 MW
Tehachapi Mountains - (Kern County, 3 projects)	31	1.3 MW	345	14.75 MW
Boulevard - (San Diego County, 3 projects)	43	2.0 MW	350	14.0 MW
Carquinez Strait - (Solano County, 1 project)			1	2.5 MW
San Gorgonio Pass - (Riverside County, 2 projects)	1	3.0 MW	1	.5 MW
TOTAL	144	10.3 MW	1165	60+ MW

By the end of 1982 approximately 1300 turbines will be installed resulting in 70 MW of generating capacity

WINDFARMS

In the hills above the plantation town of Kahuku, Oahu, Hawaii, the world's first large-scale wind energy project is being built by Windfarms Ltd. By 1985, twenty wind turbines, each capable of generating over 5,000 horsepower, will face the prevailing trade winds and begin delivering electricity to the Island of Oahu and the City and County of Honolulu.

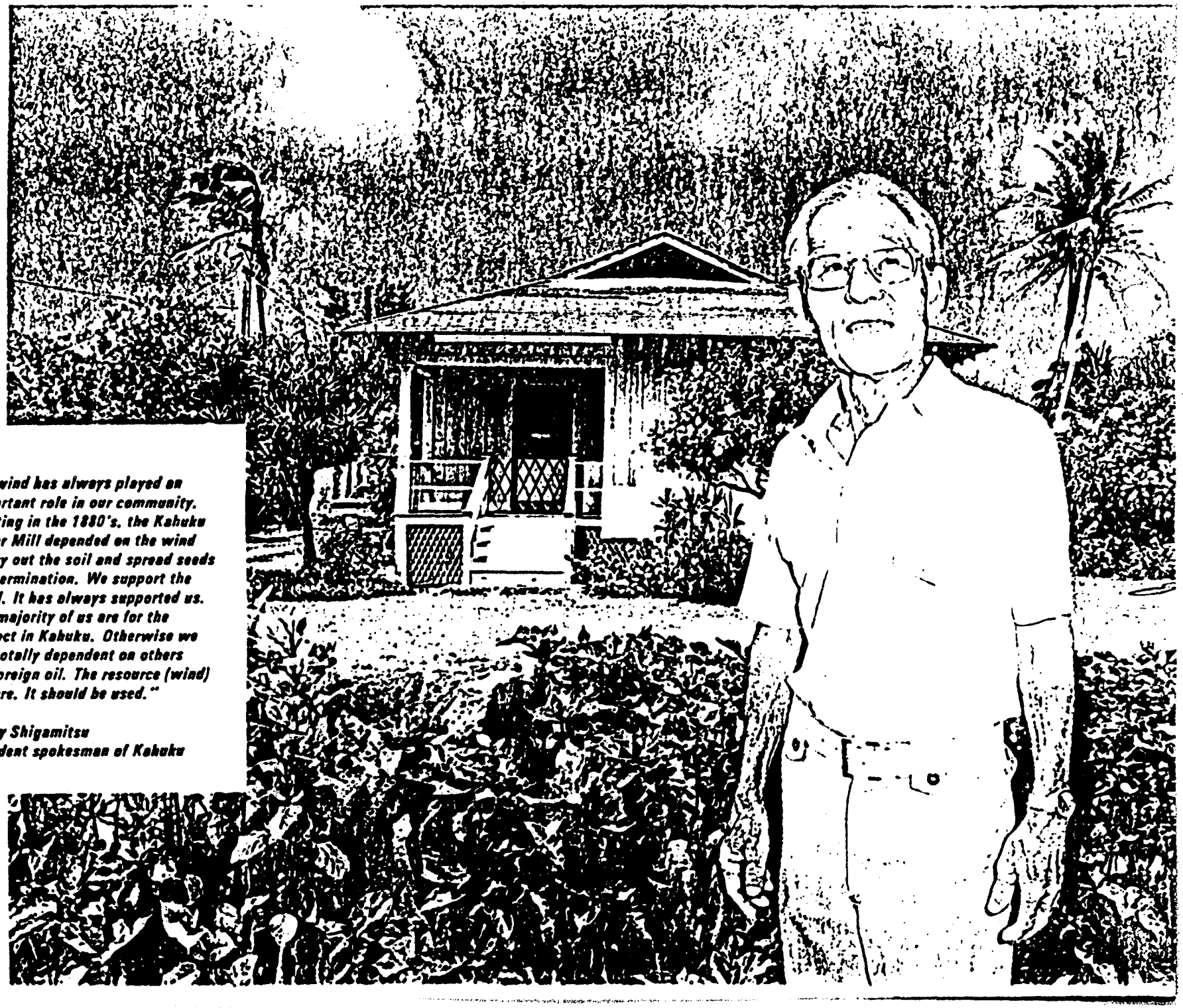
Their graceful blades will generate 8.5 percent of the electrical needs of Oahu's 800,000 residents and 4,000,000 annual visitors. Nearly one million barrels of oil will be saved each year. To accomplish this, $290 million in private capital is being committed to the project's construction.

The Kahuku Wind Energy Project is the first large-scale commercial demonstration of a renewable technology contributing to our energy needs. The project is made possible by Oahu's ideal setting (its windy north shore) and the farsightedness of Hawaiian Electric Company, Inc. At this time, it may be the most significant step any community in the world has taken toward a clean, sustainable energy future.

HAWAII

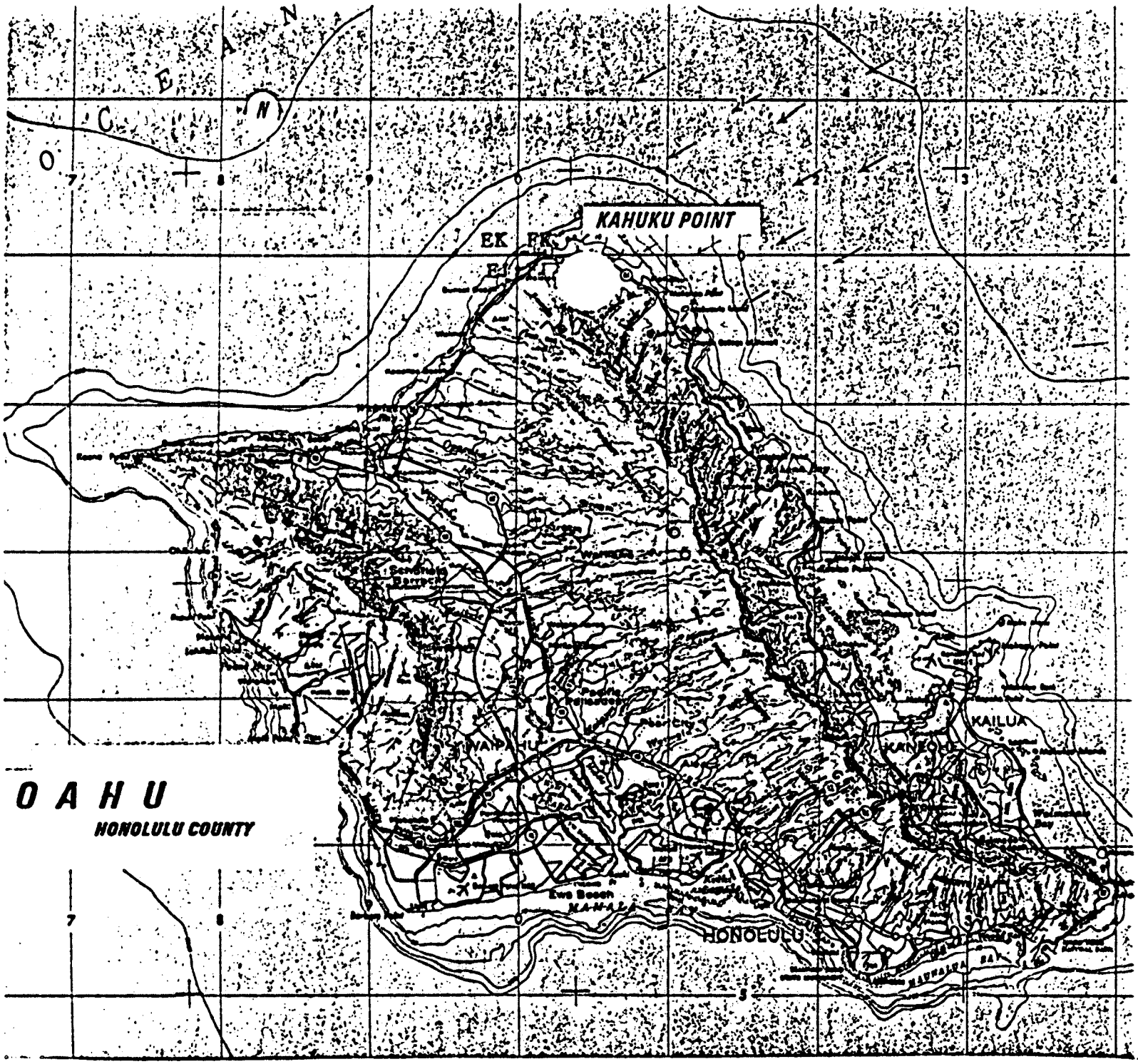
The Hawaiian Islands are ideally situated to initiate the energy transition. It was the Pacific trade winds which brought the early settlers to Hawaii. Until 100 years ago, these people depended entirely upon indigenous resources for their energy needs. But modern Hawaii, like the continental United States, has become highly dependent upon oil to power its homes and businesses. Today, the Islands' people are more than 95 percent dependent upon imported oil for their energy needs.

In Honolulu, Hawaiian Electric burns almost 10 million barrels of oil each year to fire its generators. With only 30 days' supply, it is vulnerable to even the slightest delivery interruptions. A significant step towards reduction of this dependence ocurred in 1980 when Hawaiian Electric signed a contract with Windfarms Ltd. to purchase energy from the 80-megawatt Kahuku Wind Energy Project. Hawaiian Electric will pay less for the wind energy than for an equivalent amount of oil-generated electricity.

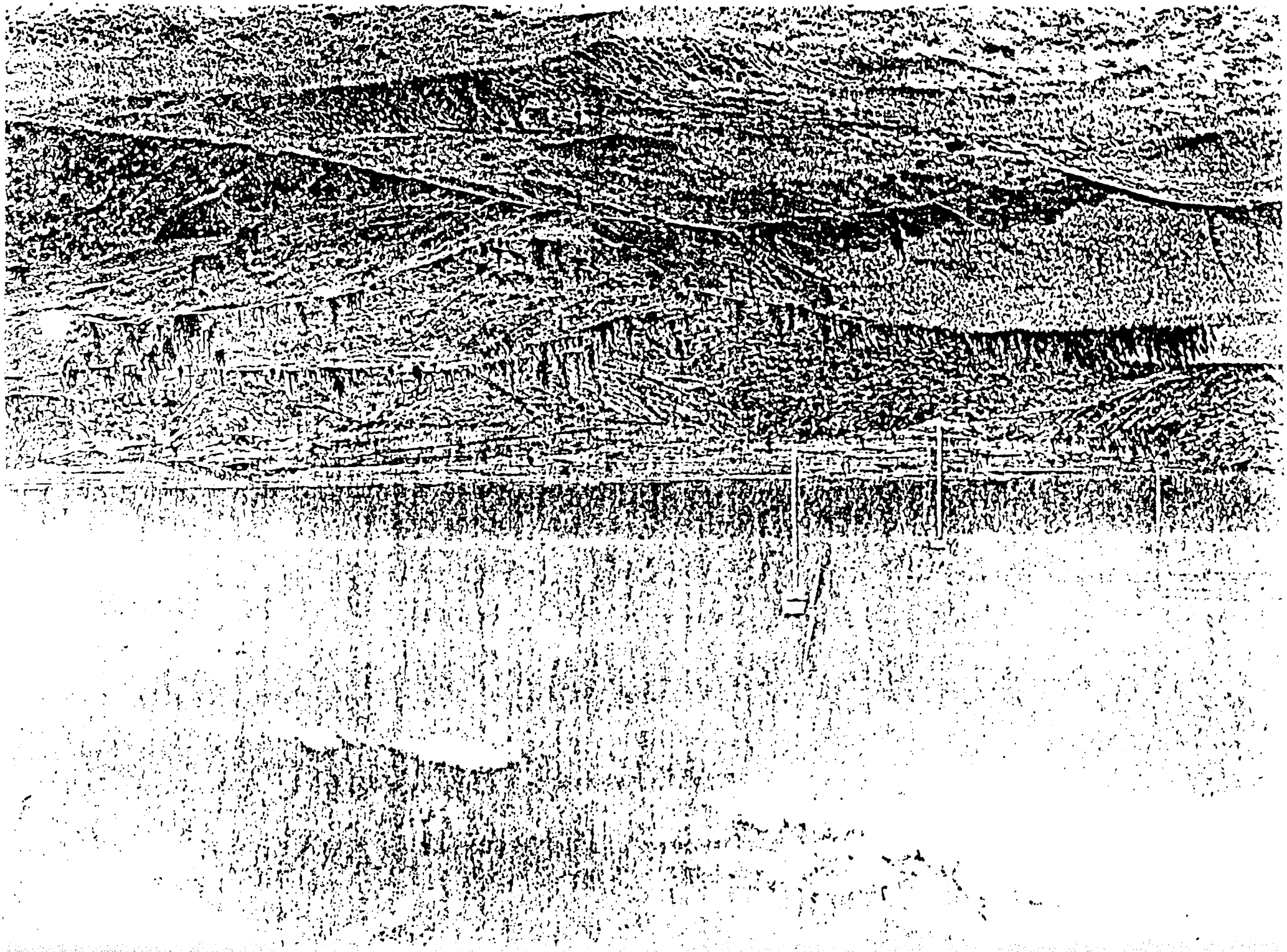


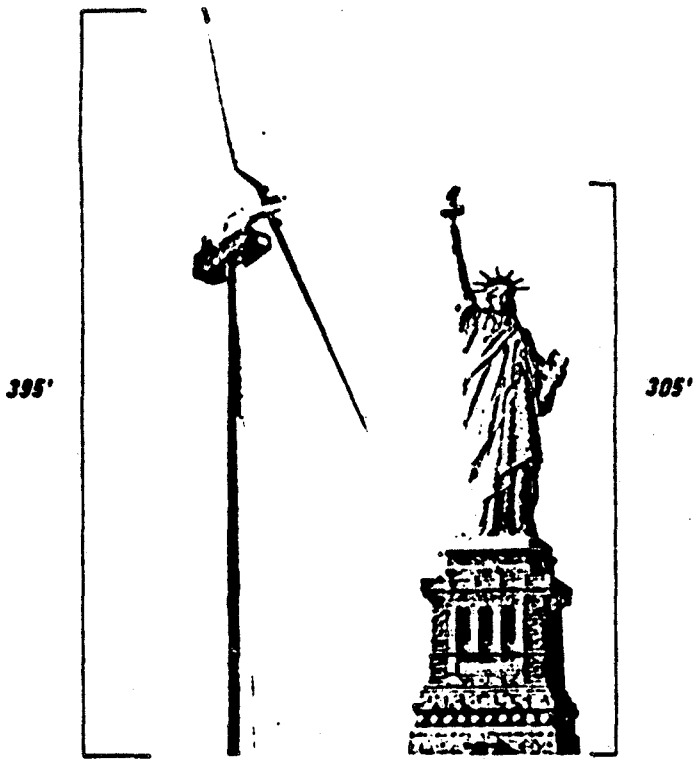
"The wind has always played an important role in our community. Starting in the 1880's, the Kahuku Sugar Mill depended on the wind to dry out the soil and spread seeds for germination. We support the wind. It has always supported us. The majority of us are for the project in Kahuku. Otherwise we are totally dependent on others for foreign oil. The resource (wind) is here. It should be used."

Harry Shigamitsu
Resident spokesman of Kahuku



KAHUKU POINT
OAHU
HONOLULU COUNTY
KAILUA
HONOLULU





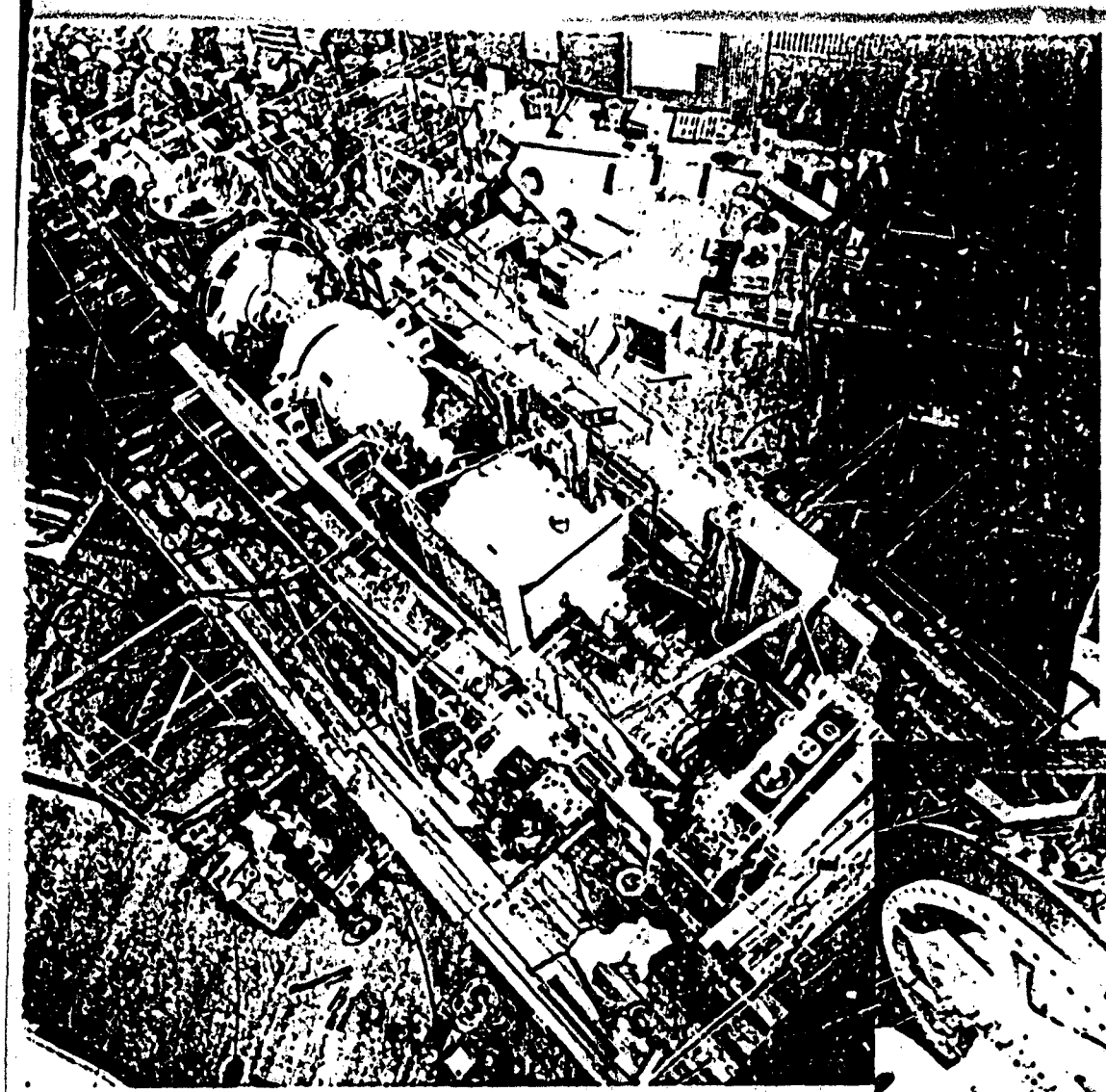
THE PROJECT

The Kahuku Wind Energy Project is situated some 30 miles from Honolulu on the northeast corner of the island. Here the prevailing trade winds first encounter the island's land mass. As the winds rise up and are forced around Mt. Kawela, they rapidly accelerate to an average velocity of 22 miles per hour. On land leased from the James S. Campbell Estate and shared with the U.S. Army, Windfarms Ltd. is building the project.

The twenty wind turbines will be erected on three ridges facing the northeasterly trades. Each turbine will consist of a 250-foot steel tubular tower anchored to a concrete foundation. Atop the tower will sit a nacelle and 270-foot rotor, or propeller.

On the site, an electrical substation will collect the energy from each turbine and increase its voltage to 138 kv for delivery to a 19-mile transmission line. At Wahiawa, the electricity will feed into the Hawaiian Electric grid.

During windfarm operation, microwave radio signals will transmit electrical and technical data from the site to the Hawaiian Electric load management center. Here the manager will dispatch the windfarm's energy to electrical customers and simultaneously reduce or shut down oil-fired generators. At times when the wind is relatively calm, the manager will bring the oil-fired units back on line.



● *The Nacelle assembly (hub mechanism, brake, transmission and generator.)*

▸ *The brake assembly*

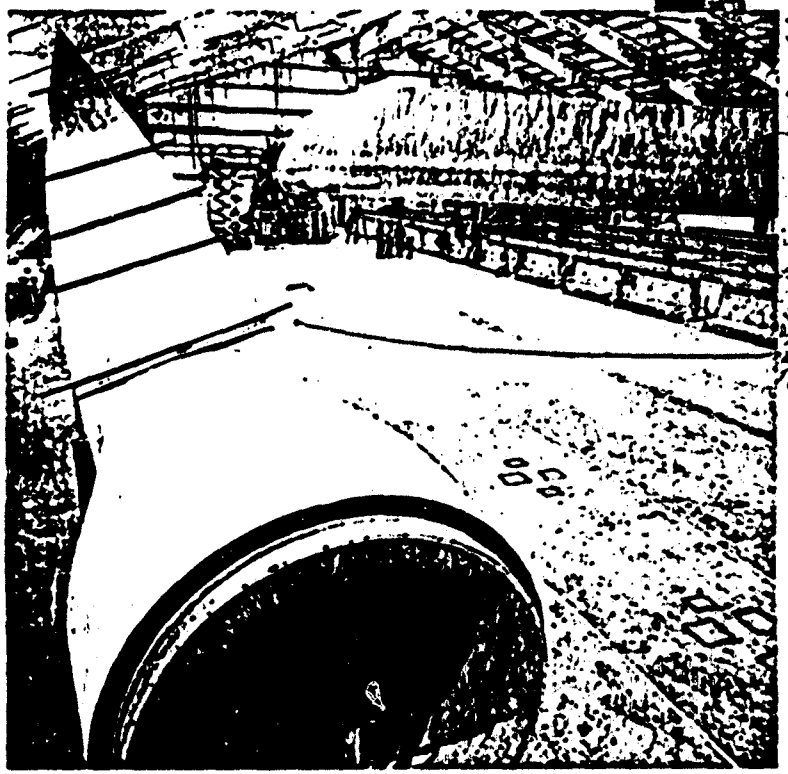
TECHNOLOGY

In order to compete economically with existing energy sources, wind turbines must utilize the most advanced aerodynamic technologies, sophisticated materials and control methods. Aircraft and aerospace companies have paved the way for these large utility turbines. Combined with more traditional electrical generating equipment, wind turbines will soon take their place as accepted power generating units.

■ Each turbine has two fiberglass blades measuring 135 feet long and weighing 15 tons. Connection to the 2-foot diameter main drive shaft is made through the hub assembly that also contains the pitch control mechanisms. Blade angles are constantly adjusted for maximum energy extraction and correct generator speed by the self-contained micro-processor computer. The wind turbine begins generation at 14 miles per hour and automatically shuts itself down when wind speeds exceed 60 miles per hour.

● The nacelle housing contains a transmission that steps the rotor's 30 revolutions per minute up to 1800 rpm. A four-megawatt generator then converts the rotating mechanical energy into electricity. ▸ The brake assembly, cooling systems and control equipment are also housed in the nacelle. The entire unit weighs 210 tons.

Engineers planning farm layout and machine locations.

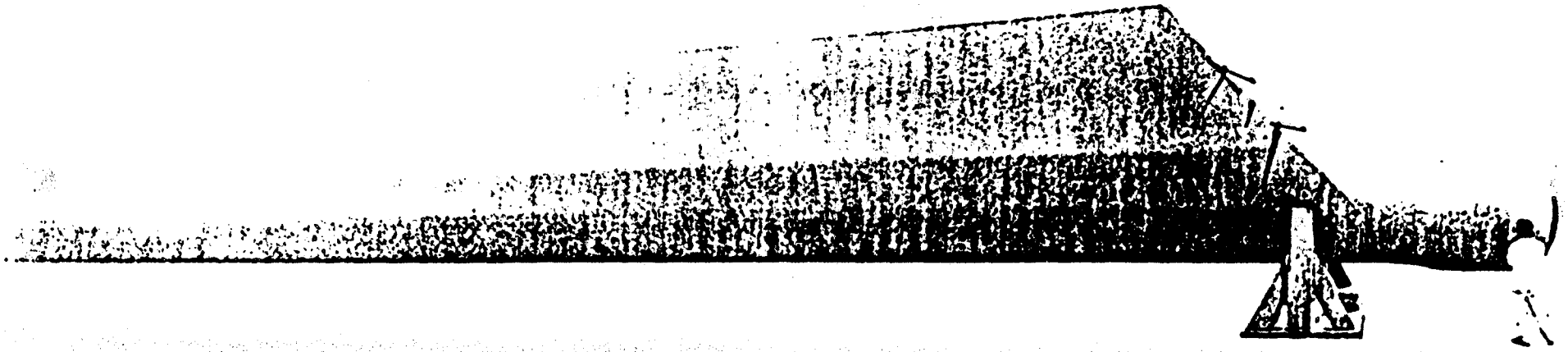


■ *Turbine blade*

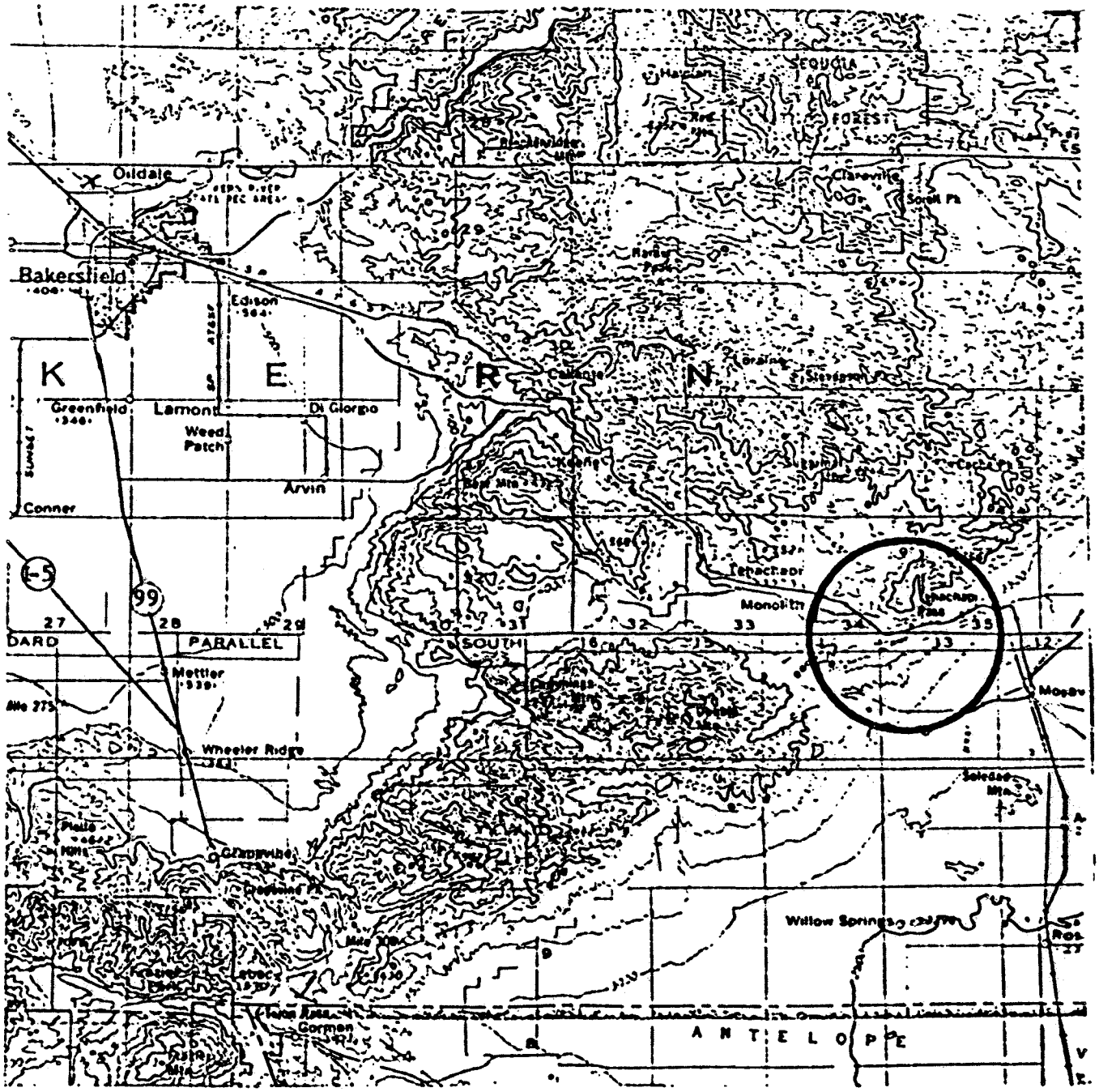
PARTICIPANTS

The Kahuku Wind Energy Project utilizes state of the art technology in meteorological assessment, wind turbine design, equipment construction and utility systems integration. Its success is due to the support of Hawaii's people and the cooperative association of many small groups and large institutions managed and organized by Windfarms Ltd.

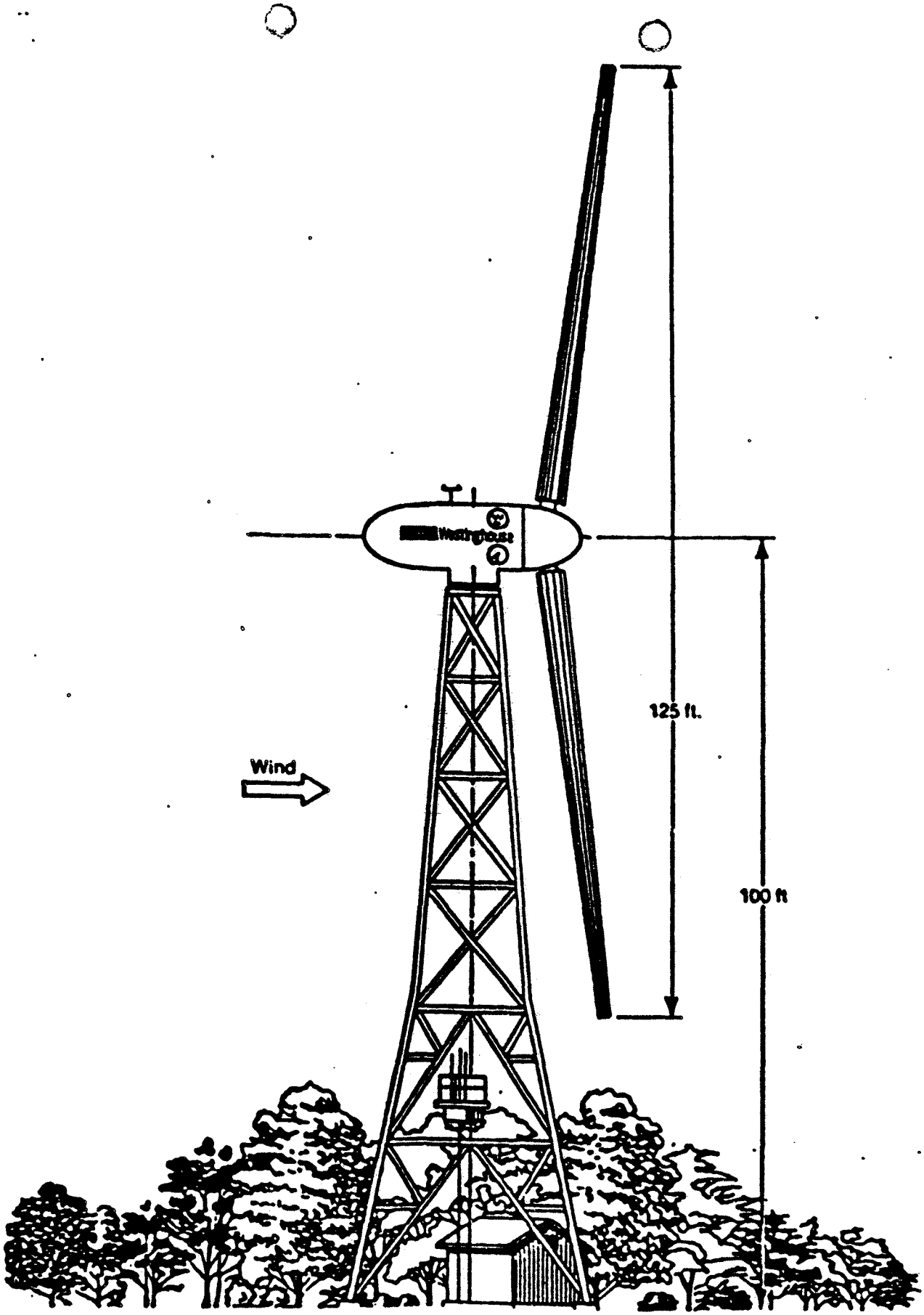
The meteorological technology is being provided by the University of Hawaii, the Meteorological Research Institute and Windfarms Ltd. The wind turbine technology was developed and is being manufactured by Swedyards in Sweden and the Hamilton Standard division of United Technologies in the United States. Hawaiian Electric Company is building the substations and transmission lines. Bechtel Power Corporation of Los Angeles is providing construction, logistics, power engineering and utility interface services. The First Boston Corporation in New York is providing project financing services.



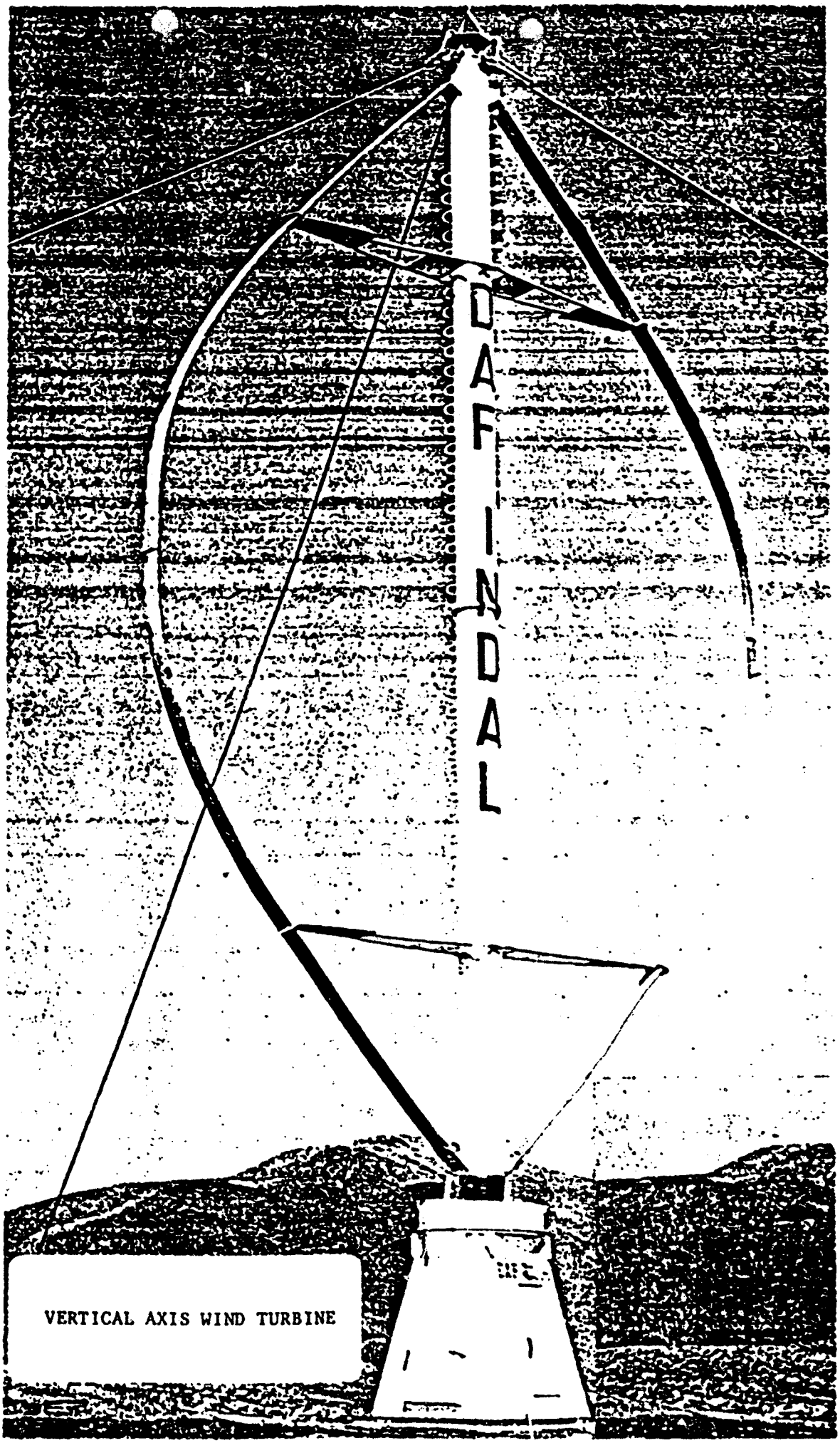
10 million dollar investment
18 acres of land
100 million capital cost



WIND 1 PROJECT LOCATION

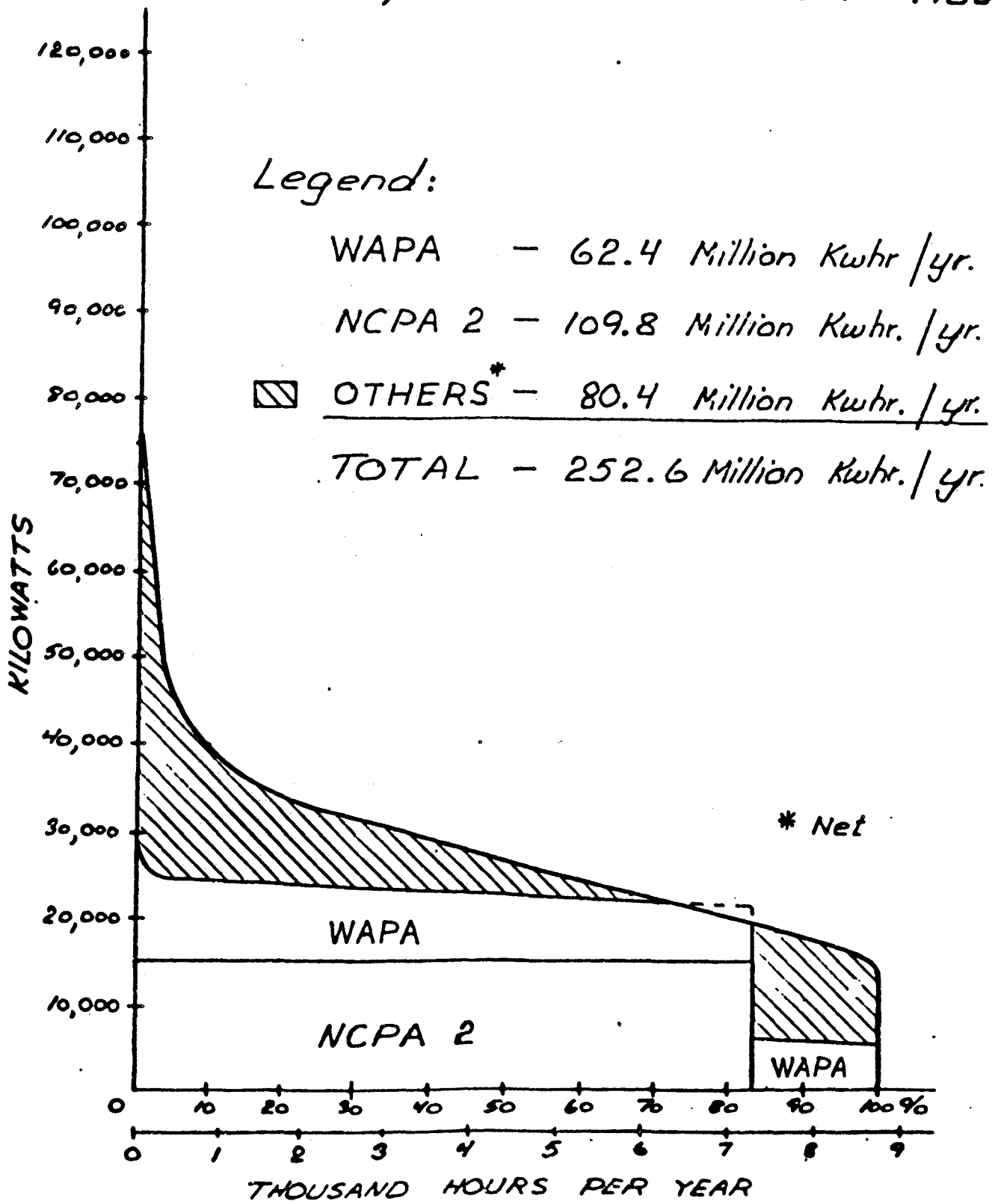


HORIZONTAL AXIS WIND TURBINE



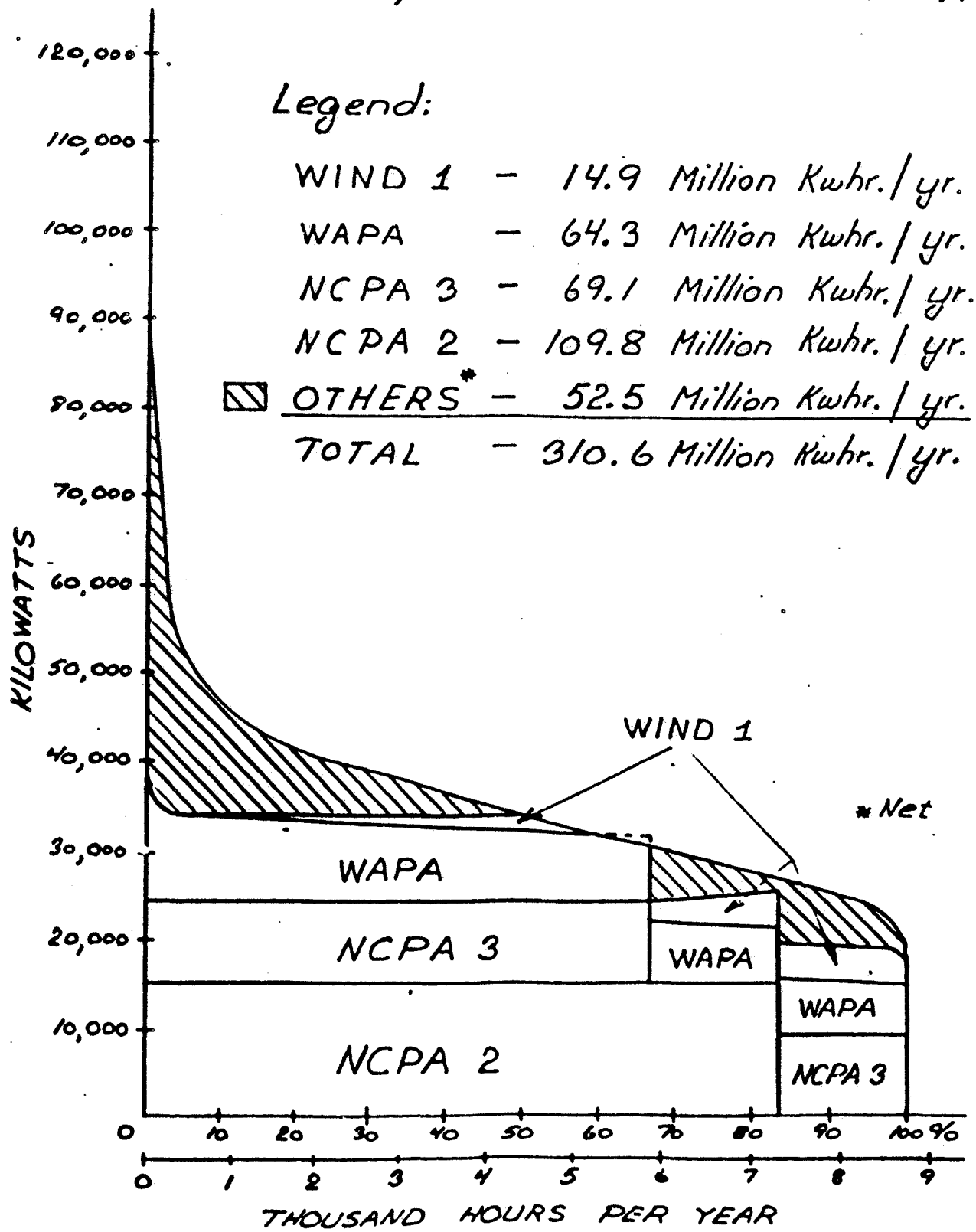
VERTICAL AXIS WIND TURBINE

PROJECTED LOAD/RESOURCE DURATION CURVE - 1983



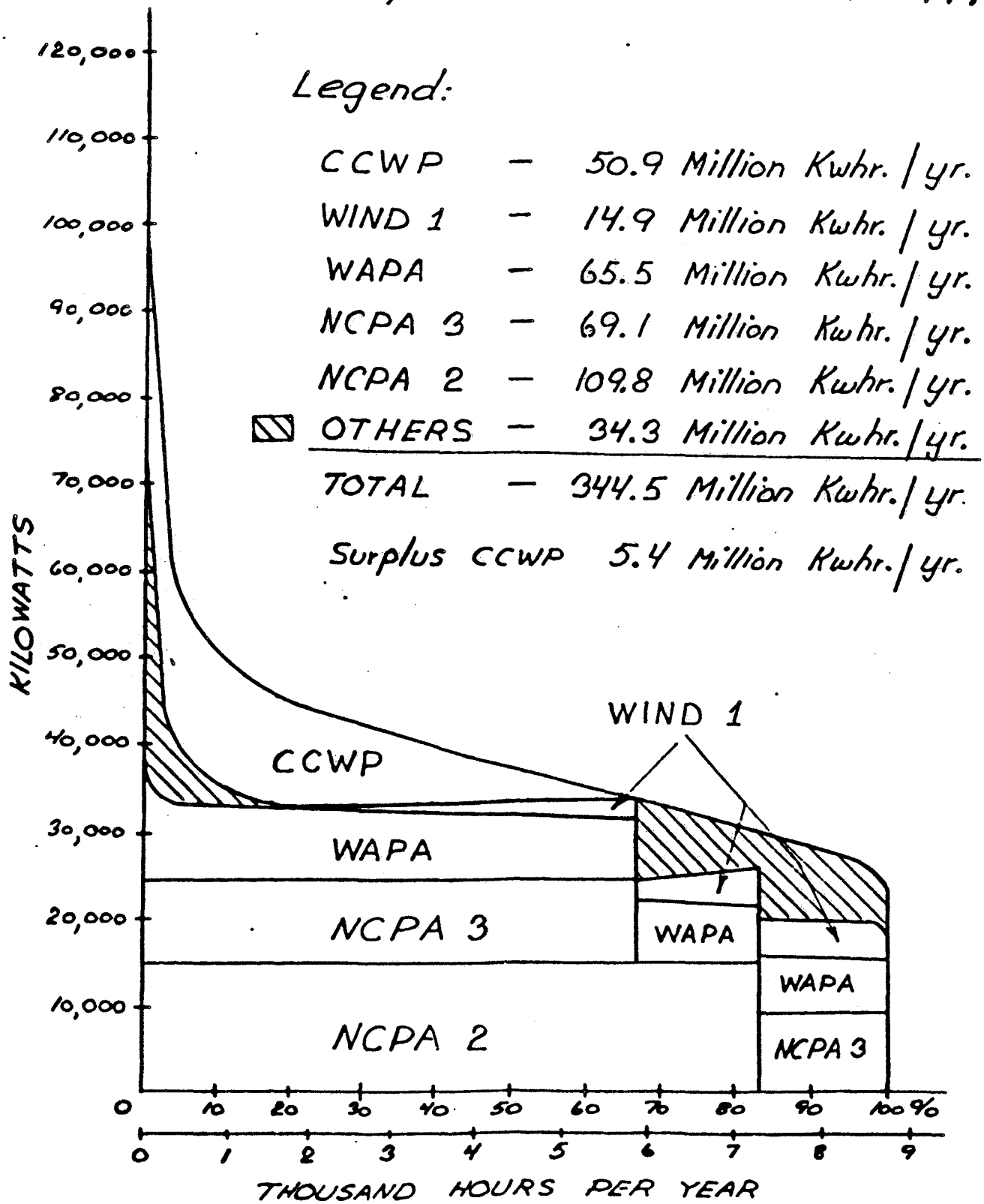
041382

PROJECTED LOAD/RESOURCE DURATION CURVE - 1990

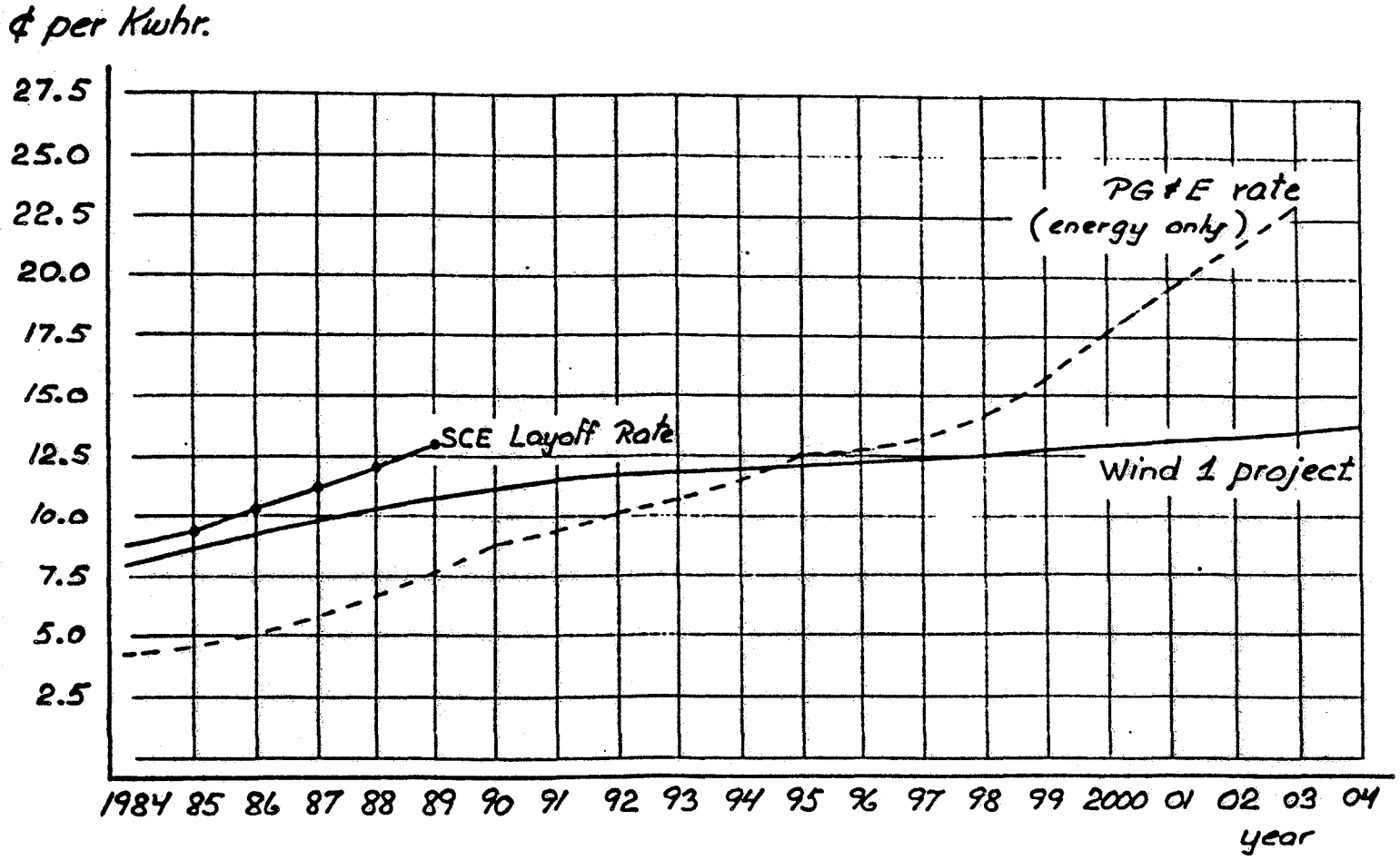


04/382

PROJECTED LOAD/RESOURCE DURATION CURVE - 1994



04/15/82


¢ per Kwhr.
27.5
25.0
22.5
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
PG&E rate
(energy only)
SCE Layoff Rate
Wind 1 project
1984 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 2000 01 02 03 04
year