

COMMUNITY WORKSHOPS
TO CONSIDER PROSPECTS FOR
ENERGY SELF-SUFFICIENCY ON
THE ISLAND OF CULEBRA,
PUERTO RICO

August 1982

NSF Grant No. OSS-8015825

Juan A. Bonnet, Jr.
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Carlos Ramos



CENTER FOR ENERGY AND ENVIRONMENT RESEARCH
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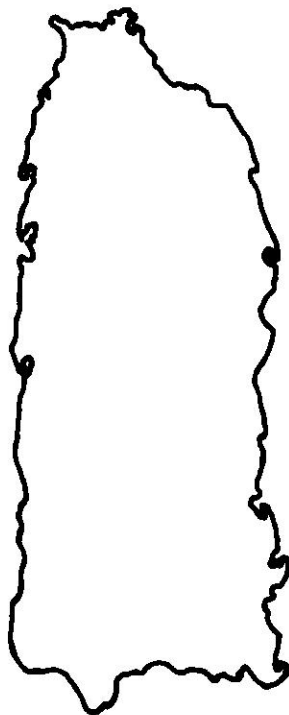
1. INTRODUCTION

The relative isolation of Culebra island, the prevailing wind and other physical factors made the area an ideal site for a demonstration project on island energy self-sufficiency. The fact that there was an ongoing wind turbine demonstration project was also another favorable condition.

On the other hand, by the end of the 1970's there was interest both in Congress and in the Department of Energy in promoting the concept of island energy self-sufficiency as a paradigm for the adoption of emerging renewable energy technologies at the national and international scale to reduce dependence on foreign oil imports. At the same time there was the Science for Citizens Program of the National Science Foundation whose purpose was "to provide scientific and technical expertise to citizens and citizens groups so that they would better understand and participate in decisions on local or regional policy issues involving science and technology". The Center for Energy and Environment Research of the University of Puerto Rico submitted a proposal to the National Science Foundation for the undertaking of workshops to consider the prospects for energy self-sufficiency for Culebra island". Funds were approved for the effort, which was carried to completion by an interdisciplinary group of scientists in three phases: planning, workshop, and project and policy evaluation phase.

Since this was to be a grass roots activity, a Community Energy Committee representing a cross section of the Culebra population

STUDY AREA



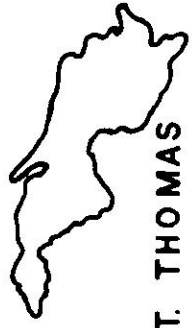
PUERTO RICO



CULEBRA



VIEQUES



ST. THOMAS

was formed. Six workshops were held with the community about conventional energy technologies, conservation and renewable energy resources*. Prior to the workshops thirty in-depth interviews were made to assess the level of information on energy matters and thus help in the development of the agendas for the workshops. As a final stage of the project 150 interviews would be made to evaluate the results of the workshop. Also the Committee would determine the ways in which it would continue to be involved in the development of renewable energy resources for Culebra.

2. CULEBRA

Culebra is the smallest of the 78 municipalities in Puerto Rico with an area of 28 square kilometers. Its 1980 population of 1265 inhabitants, represented a population increase of 72.8% during the decade, the largest for Puerto Rico. It is located at 18°18'N latitude and 65°18'N longitude or 31km east of the northeast coast of the main island of Puerto Rico and 21km north of Vieques, another outlying island-municipality. Culebra reaches a peak elevation of 198m in Montesuna.

The U.S. Navy occupation of most of Culebra and its use as a target practice, occupies a central place in the history of the island. Colonized in 1881 during the Spanish era, a settlement named San Ildelfonso was soon founded. The U.S. annexation of Puerto Rico after the Spanish-American War was later followed in 1901 by Navy presence on the island. The settlement at San Ildelfonso was moved to make place for the Navy, and the Dewey

*The original plan was to hold five workshops; but interest on wind energy was considerably more than anticipated, thus requiring a lot more time. The schedule was adjusted and an additional workshop was added.

community, named after the U.S. Admiral, was built. A second development, Clark, began in 1944.

U.S. Navy's use of Culebra Island for target practice did not actually begin until 1940. Till the mid-sixties the Island was poor and neglected and did not share in the economic development of the rest of Puerto Rico. Opposition to the Navy presence and maneuvers became a growing concern of Culebra inhabitants and later a major political controversy. This opposition intensified during the late sixties and early seventies and the "Culebra issue" gained national and even international prominence. This culminated with the cessation of U.S. Navy activities on January 1^{st.}, 1975.

Accompanying the concern regarding the U.S. Navy's presence in Culebra was a concern with the socio-economic development of the Island Municipality. Natural resources in Culebra, aside from scenic beauty and limited fisheries are almost non-existent. Average rainfall is rather low, thus accounting for a sparse forest cover and an agricultural sector limited to several hundreds heads of cattle. The remainder of the economic base consisted of a small fishing cooperative, government jobs and some commercial activity until Fomento, the Puerto Rico Economic Development Administration, promoted a manufacturing facility, Travenol Laboratories, for Culebra. The large number of jobs generated, both directly and indirectly, have contributed to high income and low unemployment rates by Puerto Rican standards. To meet the demand for workers, an immigration from other areas in Puerto Rico and the Virgin Islands has occurred. This has caused a significant housing shortage in Culebra.

A sample of the adult population reveals that 51% have more than 8 grades of schooling and that 16% have university education. The

average family income in salaries and wages is approximate \$500 per month. Twenty five percent receive government aid to supplement their income in the form of food stamps or social security benefits. An estimated 61% of the households own automobiles.

3. ENERGY PRODUCTION IN CULEBRA

The U.S. Department of Energy has also taken notice of Culebra and it has undertaken a 200Kw-wind generator demonstration -- one of four sites chosen for the Mod-OA machine. The wind generator was inaugurated on July 21, 1978. The NASA/DOE project cost approximately \$1,000,000 and is operated by the Puerto Rico Electric Power Authority, which cost-shared with approximately 20% of the total.

The wind energy demonstration project met with a problem of faulty blade design. This limited the electricity generated to 54,570KwHr during its first year of operation (July 1978-June 1979). After the blades were replaced with wooden ones in March 1981 the system picked up and 65,650KwHr were generated during the 1979-80 fiscal year*. During 1980-81 the machine generated 288,150KwHr which resulted in a 47% availability factor. From July 1, 1981 to June 4, 1982 a total of 236,900KwHr were generated. This represents a total of 645,270KwHr.

Normal supply of electricity is supplied through a submarine Cable 46Kv polyethylene vynil with 13,000Kva capacity three phase operated at 38Kv. The cable stretches from Puerto Rico to Vieques

*Even though the capacity of the wind turbine will continue to be expressed as 200KW throughout this paper, it should be noted that replacement of the blades resulted in a reduction of the rated capacity down to 150KW.

for a total cable length of 22 miles. The electricity generated in Puerto Rico (99%) comes from burning imported oil.

Culebra's peak electricity demand is approximately 800Kw. The wind generator therefore supplies approximately one-quarter of the island's peak demand and if operating, the total electricity load for Sundays. It should be noted that between the date of the inauguration of the project in 1978 and the NSF - sponsored Energy Workshops described below no attempts had been made to inform the community on the progress of the 200Kw demonstration project. Given the faulty blades, and the subsequent extended down time, a widespread view of wind generators as failures and the Culebra Wind machine in particular as a source of community embarrassment took hold.

The existence of a 200Kw wind generator in Culebra coupled with the then-current national energy policy interest in developing renewable energy technologies got scientists from the Center for Energy and Environment Research of the University of Puerto Rico interested in Culebra as a model for island energy self-sufficiency.

4. THE CULEBRA ENERGY WORKSHOPS

Several years back, the United States Congress and the US Department of Energy were very interested in promoting the concept of island energy self-sufficient as a paradigm for the adoption of emerging renewable energy technologies at the national and international scale to reduce dependence of foreign oil imports. Culebra, with its abundant solar insolation and wind resource, its small scale, and isolation, provided adequate physical and climatological conditions to explore the concept of energy self-sufficiency.

At the same time there was a Science for Citizens Program of the National Science Foundation whose objectives were to provide scientific and technical expertise to citizens and citizens groups so that they would better understand and participate in decisions on local or regional policy issues involving science and technology. Thus the situation seemed amenable for further exploration and the Center for Energy and Environment Research submitted a proposal to the National Science Foundation for the undertaking of "Workshops to Consider the Prospects for Energy Self-sufficiency for Culebra Island".

The project obtained \$44,000 in funding covering the period January 15, 1981-April 30, 1982. The primary objective of the project was for CEER to provide the community of Culebra with the requisite scientific and technical assistance needed for an understanding of the technological, economic and socio-political issues involved in the use and implementation of renewable energy technologies.

The achievement of this primary objectives was obtained through the following specific goals:

- (1) To increase the contacts of the citizenry of Culebra with the scientific community in a manner which demonstrates the importance and relevance of the natural and social sciences and of technology to issues of public interest i.e. the reduction of the dependence on imported petroleum through the adoption of renewable energy technologies.

- (2) To provide an experience of interactions between scientists, citizens and policy makers through a discussion of the energy future of Culebra permitting the different categories of participants to see the views of each other. Such an experience is quite

uncommon in Puerto Rico and can be transferred to other communities.

(3) To provide policy makers with information on community goals and needs with respect to the adoption of renewable energy technologies. The survey results and the findings of the final report provide the information needed to meet this goal.

The project consisted of three phases: Planning Phase, Workshop Phase and Project and Policy Evaluation Phase. Five participants from the Center for Energy and Environment Research constituted the task force for the project. This interdisciplinary task force consisted of an engineer, an economist, a regional planner, a community anthropologist and a political scientist.

A Community Energy Committee (CEC) composed of Culebra citizens was chosen by the community itself. Although the size of the CEC fluctuated throughout the project, on the average there were six members including the Hon. Anastacio Soto, the Mayor, who served ex-officio. Ramón Feliciano, the former Mayor also served on the Committee. The responsibilities of the Community Energy Committee would be to oversee the whole effort. More specifically they were to plan the workshops, to hold a final evaluation workshop and adopt an independent course of action for future activities of the Committee.

For all these activities the Committee counted with the advice of the task force members.

4.1 Planning Phase

During the planning phase of the project the Community Energy Committee was organized. Its duties would be the following: (a)

to plan and hold five workshops to involve the community, scientists, and government; (b) to help ascertain the perceptions of Culebrans about the energy problem and their information level on the subject; (c) to hold the last workshop to evaluate the effectiveness of the project and to formulate recommendations for future action by the Committee.

As part of the Planning Phase - thirty interviews of Culebra citizens were undertaken to obtain information on the community's energy use patterns, the knowledge about alternative energy technologies and the opinions regarding those strategies most viable for the solution of Culebra's energy problems.

The main findings of the interviews included:

- (1) High costs were perceived as major problems in the area of electricity and gasoline;
- (2) Water shortage took priority over energy problems as areas of community concern;
- (3) Limited knowledge and great skepticism over past community efforts to deal with Culebra's problems;
- (4) Perception that the government, even though ineffective, has the main responsibility for taking action to solve community problems;
- (5) Widespread knowledge of wind as an electric energy source, even though most interviewed saw it as a failure;
- (6) Surprisingly little knowledge about conventional energy sources;

- (7) Perception of wind and solar energy as the most viable alternate energy sources for Culebra;
- (8) A substantial majority expressed interest in receiving additional information about alternate energy sources;
- (9) Two thirds of those interviewed have already taken steps to conserve energy;
- (10) Substantial interest in obtaining more information on energy conservation techniques.

Besides this knowledge about the perceptions and of the energy problems and the information levels of the citizenry, an assessment was made as to the prospects for community action efforts in Culebra. It was found that the socio-cultural factors and political environment within which the project was to be developed was rather negative. There was a lack of a tradition of group civic action; a sharp political division, and a distrust of government.

This background information and the interview findings served as a basis for the development of the agendas and the timing of the workshops.

Since these activities would require an active participation from the Committee, a training session was planned to familiarize CEC members with renewable energy technologies. The session was held at CEER facilities in Mayaguez.

As to the workshops themselves, promotional efforts used to attain as much participation as possible started with a direct mailing (about 300 pieces). A second mailing would be sent to remind them of the activity. Meanwhile, spot announcements by the local radio

station WLID (as a public service). CEER Director, Dr. Juan A. Bonnet, Jr., taped a half-hour interview with Professor Luis A. Passalacqua, member of the task force discussing the project. The interview was run twice on Radio WLID in Culebra. Dr. Bonnet also mentioned the project's objectives once on radio and once on TV, both occasions in San Juan. Also personal calls from task force members to Committee members would be made to keep the interest on the activity and to discuss and arrange the logistics for the activities.

4.2 Workshop Phase

Designed to fill the knowledge gap on conventional energy sources, the first workshop has as its theme "Energy Production and Utilization in Puerto Rico and Culebra". Materials distributed included diagrams on conventional energy sources; also a 30-minute film was shown and three speakers talked about various aspects of energy in Culebra. Emphasis was given to explaining the conventional energy technologies. Attendance to this activity averaged from 25 to 30 persons, setting the pattern for the attendance to the rest of the workshops. The Community Energy Committee thought that the number of people attending was high, by Culebra standards. There was a lively discussion period and the participants expressed a desire to know more about renewable energy technologies, especially about the wind turbine.

An evaluation conducted at the workshop revealed that (1) direct mailing was the most effective mean of informing the citizens about the activity; (2) films were liked the most; (3) a substantial majority found the workshops useful and were willing to attend the next ones.

The second workshop was on wind energy and it included a detailed presentation by a staff member of the Puerto Rico Electric Power Authority outlining the origins of the Mod OA wind demonstration project and stressing its experimental nature. A speaker from the Puerto Rico Office of Energy described the different wind turbines available for residential use.

A majority of the participants in this activity had not been to the previous workshop but they appeared to possess greater prior knowledge about the subject.

The third workshop was about biomass and bioconversion. The first lecturer was the owner of a cattle manure digester who described his experience with anaerobic digestion. The fact that he had a scale model greatly facilitated his presentation. The other lecturer talked about biomass and described the different ways to get energy from it ranging from wood burning to alcohol distillation. The fact that there were many students among the participants contributed to an interesting questions and answers period.

The fourth workshop was devoted to solar energy and to energy conservation. A lecture was given on the nature of solar water heaters and the steps involved in their construction (a detailed booklet on the subject was distributed). The same lecture included the description of a desalting unit, an artifact in which fresh water is taken out of sea water by evaporation. On energy conservation there was a conference on passive cooling of structures (cooling without mechanical help) and another conference on energy conservation in the use of automobiles and home appliances.

The fifth workshop which dealt with the prospect for increased energy self-sufficiency for Culebra was held in a somewhat different format. Members of the task force explained briefly the

changes occurred in the energy self-sufficiency concept, as an expressed policy of the US Congress, the US Department of Energy and changes in the Science for Citizens Program of the National Science Foundation. The results of the 1980 presidential elections brought about a change in energy policy, reducing the government support in the search for renewable energy resources. However, the need for Culebra to press for solutions was emphasized specially now that a ceiling had been put to the subsidy for consumers of less than 425 kilowatt hours of electricity per month. The members of the task force stated that the Center would be willing to help financially to the extent that project funds permitted, and that it would be willing to cooperate with the Committee after the completion of the project.

The task force and the Committee went on to describe to the workshop participants the possible future activities that could be undertaken by the Committee:

(1) Since energy conservation was a well received topic during the workshop and since there is always room for more energy conservation, the suggestion was put forth to develop a citizens education project. As part of this activity, brochures could be prepared dealing with passive cooling for energy conservation in existing and new structures.

(2) As evinced by the existence of a wind demonstration project in Culebra, the wind regime seems to have potential as an energy source. The suggestion was made to evaluate wind energy potential in various parts of the island.

(3) The availability of substantial amounts of insolation provides favorable conditions for the use of solar water heaters. Thus a

workshop on the construction of solar water heaters was suggested.*

(4) The scarcity of fresh water in Culebra, coupled with the abundance of insolation lead to the suggestion of an assessment of the potential of solar deslinators to produce fresh water through evaporation. If the assessment proved possitive, a workshop on the construction of desalinators would be held.

The workshop participants were divided in three groups where the alternatives were discussed at length. Each group reported its preferences back to the Committee, which in turn would assess them and hold a final follow-up workshop to lay down the future course of action for the Committee.

4.3 Project and Policy Evaluation Phase

The final phase of the project, included a 150-person survey of the Culebra population and one workshop to discuss subsequent activities of the Community Energy Committee. The survey was designed to document the impact of the workshops on residents of Culebra and to provide planning data for the CEC for use in the implementation of community based alternate energy projects.

A sample of 150 persons was selected from the 1980 Electoral Lists of the Municipality of Culebra. This source was selected because it provided the most recent and accessible data. With the information on residence and kinship patterns, it was then possible the selection of the sample based on one person per household. This

*However, the lack of water pressure in the Culebra system renders inapplicable the thermosyphon principle in the solar hot water heaters, thus limiting their potential use.

sample represents 150 households or approximately 50% of the total number of residential units as well as 13% of the population.

The principal conclusions of the survey were as follows: (See graphs)

(1) The publicity used was highly effective in reaching 70% of the survey's sample. In other words, three out of four households knew that alternative energy workshops were offered in Culebra. However, only 11% of the total sample attended an average of two workshops. All but one of those that attended evaluated positively the workshop's content.

(2) While 88% of the total population were interested in attending the Project's last workshop, previous attendance advised caution concerning these expectations. If future activities are to be planned that desire widespread citizen participation, they should be organized mindful of the main reason for non-attendance: work obligations. It is therefore suggested that future activities be held in different work settings.

(3) The great majority of interviewees feel that Culebra has energy-related problems having to do with electricity, gasoline and propane gas. However, when asked to evaluate the magnitude of these specific problems in terms of cost and inconveniences, gasoline is rated as a very serious problem, propane gas as a serious one and electricity as not too serious. This changing ranking may be due to two factors. First, large numbers of residents receive subsidies that offset having to pay the full cost of electricity. Second, the installation of the under-water cable has greatly minimized past inconveniences and problems related to electricity.

(4) The interviewed population lacks basic information about alternative energy resources. Additional information is principally solicited in the areas of wind energy, oil, coal, and solar energy. Moreover, the interviewees are interested in obtaining additional information about energy sources, particularly information dealing with wind, ocean thermal, and solar energy, and responded very positively to having experimental alternate energy projects located in Culebra. They are of the opinion that these projects should be financed principally by the Federal government and initiated by government agencies.

(5) The sample reported as having information about a variety of community-action groups, but few were informed about the Community Energy Committee. The Committee will have to correct this situation and in addition deal with a population that posits financial and planning responsibilities for such endeavor in agents or agencies outside the community.

(6) Finally, the majority of Culebrans believe that energy should be conserved, and indicated that they personally have taken steps in this direction. Nonetheless, the overwhelming majority of the sample is interested in additional information about energy-conservation measures.

There was a sixth follow-up workshop to discuss and decide upon the future activities in which the Community Energy Committee would be involved. Even though the concept of energy self-sufficiency was not receiving support from the federal government, Community Energy Committee would nonetheless adopt it as a the overall goal for its future efforts: all energy oriented efforts would be striving toward more energy self sufficiency. The Committee will be looking for support in this regard. With the information on renewable energy resources received in the previous

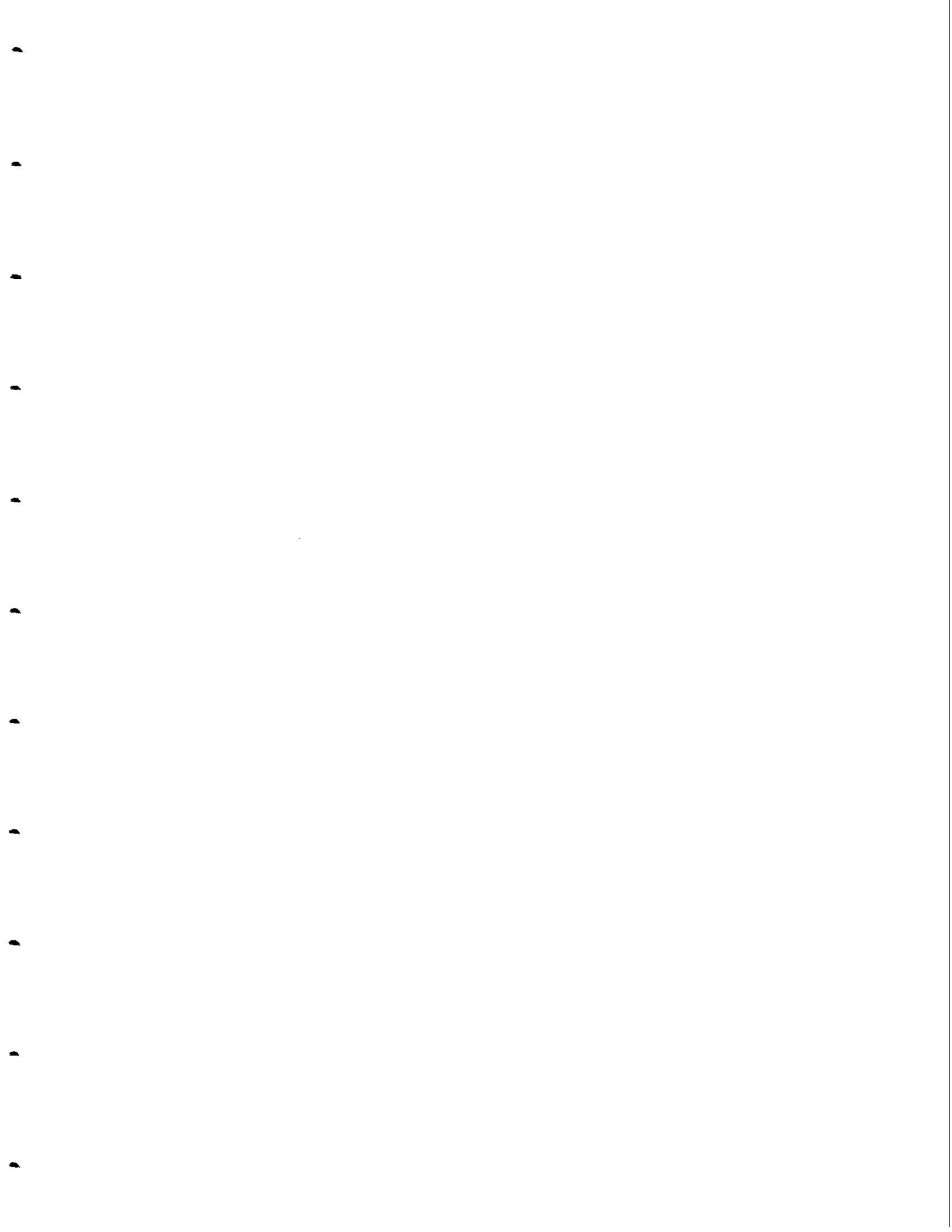
workshops, the participants engaged in a thorough and realistic discussion of the potential for each of these technologies for Culebra. It was finally decided that the CEC will take the following actions that although small ones, they would constitute steps in the right direction to try to ameliorate the Culebra energy problem.

(1) There was an expressed preference on the part of those interviewed in the population survey for wind as an energy source. Moreover Culebra is one of the places in Puerto Rico where average wind speed is the highest. But possibilities for effective use of the wind will vary with the topography, the forest cover and man made structures. Therefore measurements of wind speed have to be site specific and observations should be for not less than one year thus to encompass the whole climatic cycle. For this effort the Center for Energy and Environment Research will provide two anemometers (and odometers) and the two respective towers. Advice will be provided to the Committee as to the location of the towers and the recording of the observations thus to assure more effective wind measurements.

(2) Since one of the findings of the in-depth interviews was that there was a substantial interest in receiving more information on energy conservation, the Committee also decided to go ahead with a public education program on the subject. In this respect the task force would prepare a slide show that the Committee would use in presentations to various groups in Culebra.

5. EVALUATION OF THE COMMUNITY'S RESPONSE

Before going into the analysis of the community response, it is advisable to examine the self-evaluation that the Community Energy Committee made of the whole effort. All members agreed



for biogas, 34% for OTEC and 33% for photovoltaics. It can therefore be surmised that the existence of a wind demonstration project in Culebra had a direct influence in increasing knowledge regarding the potential of wind energy.

Although the majority of those interviewed (55%) identified the principal purpose of the 200Kw wind generator as experimental rather than to generate additional electricity (29% identified it as such), the in-depth interviews reveals little knowledge on the nature or purpose of the demonstration project.

Given the operational problems with the experimental wind generator and the lack of community awareness efforts to explain them it is not surprising that it was considered as a source of community embarrassment. This view was widespread during the beginning of the project and was ubiquitous in the in-depth interviews. The second workshop on wind energy permitted PREPA officials explaining the purpose and achievements of the demonstration project to restore a sense of community pride to those citizens and community leaders who were present. Still, during the November 1981 survey, 61% of those surveyed viewed unfavorably the success of the wind generator. The reasons given for this response included (a) the very experimental nature of the project in that certain technical problems had not yet been resolved; (b) that the wind generator is defective and simply does not function; (c) that it does not generate sufficient electricity for the island's needs.

Somewhat paradoxically, given the community's negative evaluation of the success of the 200Kw wind generator, wind energy was chosen as the energy alternative with greatest additional potential for Culebra. Over two-thirds of those interviewed favor it, compared with 50% or less for any other technology, renewable or otherwise. But there appears to be a close rank order correlation between the

information available to interviewees on alternative technologies and their evaluation of their potential.

In summary, the community's response to the 200Kw wind generator appears ambivalent. The very existence of the project provides indication of the potential of the wind resource for generating electricity. Nevertheless, performance problems coupled with the lack of adequate public communications on the wind generator have led to disappointments.

6. RECOMMENDATIONS

The levels of knowledge of the community and its perceptions as to renewable energy resources and the wind experiment has been discussed. There is no doubt that wind is favorably perceived by Culebrans. However, our analysis of the response of the Culebra community to the 200Kw Mod-0A wind generator reveals the need for public awareness programs targeted to explain the progress of similar demonstration projects to inhabitants of surrounding areas. This is particularly true for projects located in isolated rural areas, such as Culebra. In such cases, the community comes to be identified in the minds of outsiders as the site of the demonstration. Social acceptability is important to avoid political barriers to further development of unconventional energy technologies.

The NSF-sponsored project on "Workshops to Consider the Prospects for Energy Self-Sufficiency for Culebra Island" provided the requisite community awareness program to accompany the wind experiment. Although now-current national energy policy does not contemplate future solar and renewable demonstration projects, the reasons that led to the adoption of the energy self-sufficiency concept are still there as far as Culebra is concerned, namely a

one hundred percent dependence on foreign oil and a subsidy for low consumers of electricity that is going to be harder to qualify for. Therefore, the situation may change and new demonstration projects may develop. In this case we recommend that:

(1) The technical and economic monitoring of the project's progress be accompanied by an evaluation of its social acceptability.

(2) That the inhabitants of the surrounding community be kept well-informed on the goals and progress of the demonstration project.

(3) That the preferences of the community be given high consideration in determining the renewable resources to be used to obtain an energy self-sufficiency. In the case of Culebra these preferences are wind, OTEC, solar cells, biogas and biomass.

In more general terms there are other recommendations we would like to make for future efforts dealing with the assessment of community response to renewable energy technologies under similar circumstances:

(1) The technical aspects of renewable and conventional energy resources are not an easy subject for the average person. Since the level of information of the participants on energy matters is apt to be low and group participation smaller than anticipated, disappointment is likely to develop as the project evolves. A priority knowledge of this possible outcome should enable project staff to take steps to minimize the effects of such disappointment.

(2) As in other group actions, the prime movers at the community level are always a few persons. To keep up the interest of this

group, a systematic follow up is needed. But care should be exercised so as to maintain the expectations of the local people at reasonable levels.

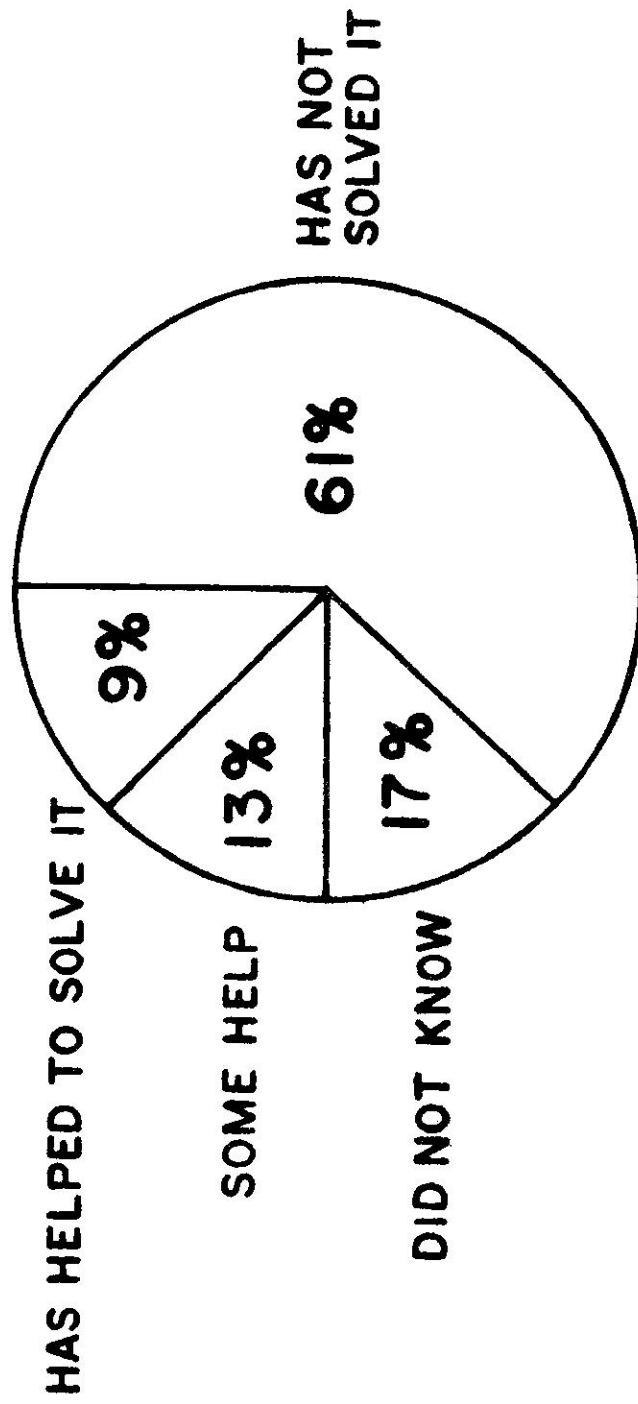
(3) In dealing with isolated areas, the logistics for the project become more important. Adequate advance planning, coupled with a flexible attitude in the face of adverse results, are a definite plus.

(4) As soon as trends that may affect project objectives are detected, the local people should be informed.

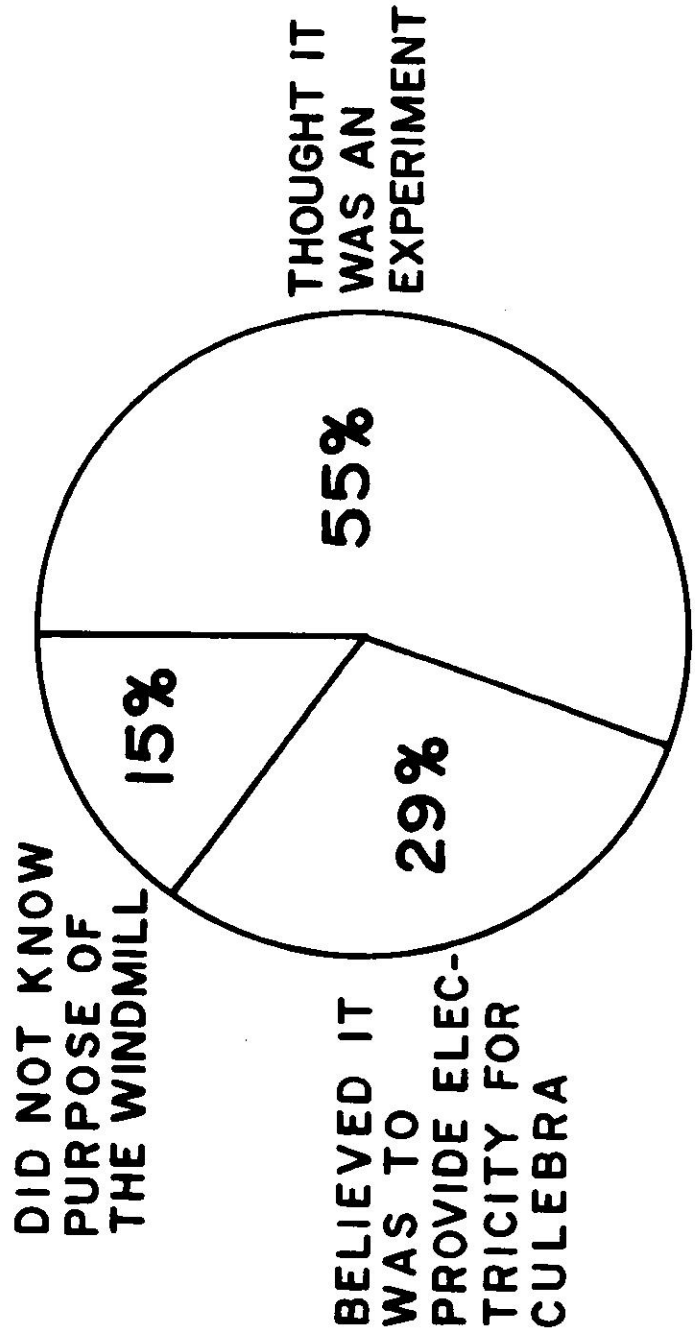
7. ACKNOWLEDGEMENTS

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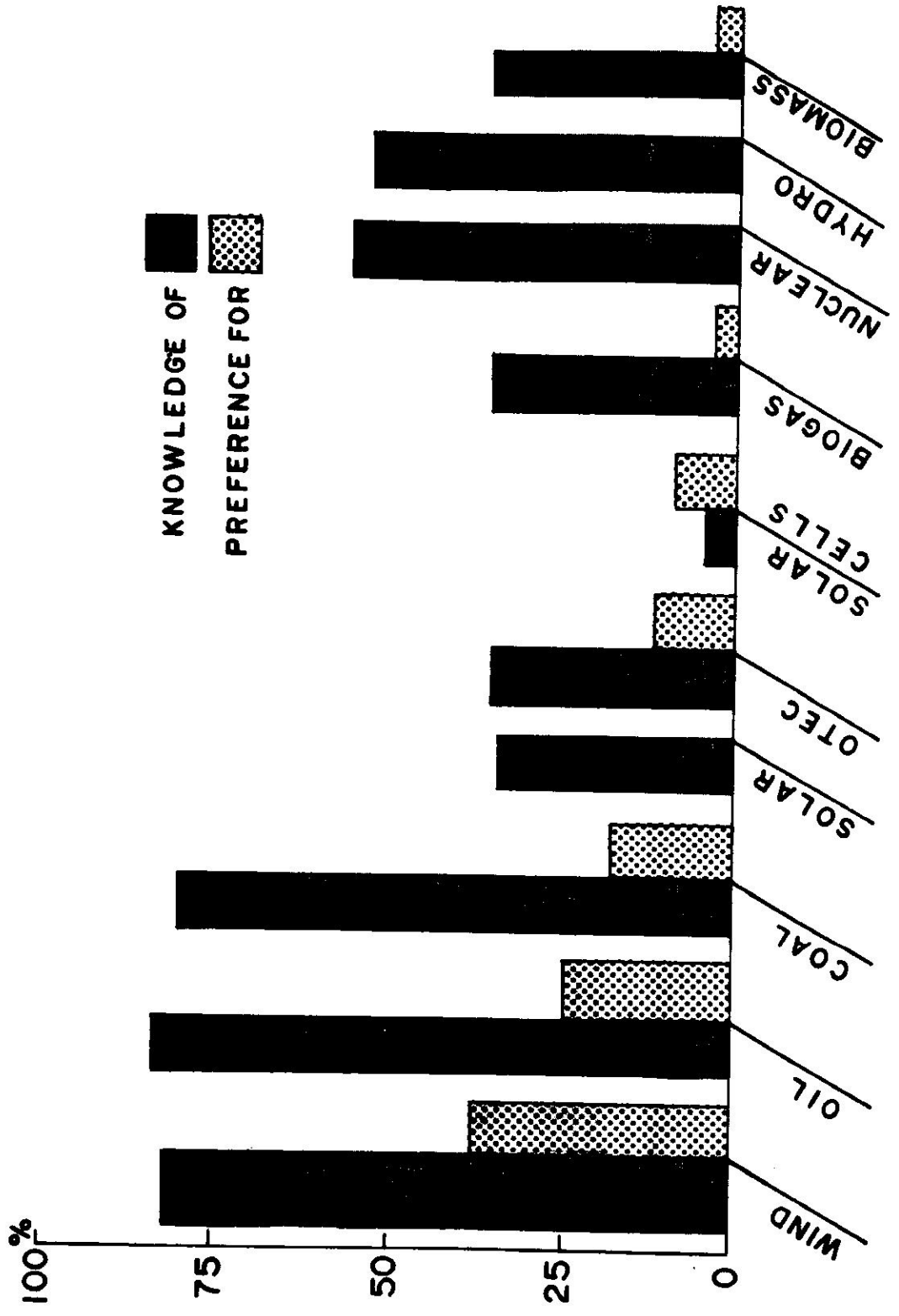
**EFFECTIVENESS OF THE WIND TURBINE
TO SOLVE THE ELECTRICITY PROBLEMS**



**COMMUNITY PERCEPTION OF THE PRINCIPAL
PURPOSE OF THE WINDMILL INSTALLATION**



KNOWLEDGE AND PREFERENCE IN REGARD TO ENERGY SOURCES FOR ELECTRICITY GENERATION



ENERGY RESOURCE ABOUT WHICH ADDITIONAL
INFORMATION IS WANTED

