147 DEVELOPMENT OF ALTERNATIVE ENERGY SCIENCE AND ENGINEERING IN THE CARIBBEAN (Grant No. 1NT-025599) FINAL REPORT Submitted to NATIONAL SCIENCE FOUNDATION by Dr. Juan A. Bonnet, Jr. Principal Investigator and Chairman UNICA Science and Technology Commission September 30, 1982

CENTER FOR ENERGY AND ENVIRONMENT RESEARCH

DEVELOPMENT OF ALTERNATIVE ENERGY SCIENCE AND ENGINEERING IN THE CARIBBEAN (Grant No. T-802593) FINAL REPORT Submitted to NATIONAL SCIENCE FOUNDATION By Dr. Juan A. Bonnet, Jr. Principal Investigator and Chairman UNICA Science and Technology Commission September 30, 1982

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DEVELOPMENT OF ALTERNATIVE ENERGY SCIENCE AND ENGINEERING IN THE CARIBBEAN EXECUTIVE SUMMARY

Today, as in the past, the Caribbean area remains of critical strategic importance to the United States and the rest of the world.

This hemisphere, the region's geographic vulnerability is accentified by its dependence on imported petroleum and petroleum products to satisfy the energy needs of industry, commerce, households, and other vital activities of society. Thus, the communities of the Caribbean Basin have been greatly impacted by the increases in the price of imported fossil fuels. On the other hand, the region is blessed year-long with large amounts of natural energies including solar, wind, ocean, biomass, and in some areas, geothermal.

The purpose of this project was to develop the scientific and engineering capabilities of the universities and research institutes of the Caribbean region. The project used a unique institutional resource, the Association of Caribbean Universities and Research Institutes (UNICA), to foster a cooperative research effort aimed at increasing the capabilities of Caribbean institutions to assist in the introduction of alternative energy solutions into the region.

The research workshop format has been used, and a network of scientists and engineers working in energy was established to promote cooperation, interchange of technical information, and development of joint projects. Two workshops were carried out on the most promising energy alternatives. The first was on wind energy in Barbados on December 6-9, 1981; the second on tropical biomass, held in Puerto Rico on April 28-29, 1982. In each of the workshops, a list of needs and priorities in education and training, research and development, and demonstration projects were worked out, as reported in Appendices D and E. Proceedings of both workshops are in preparation for publication.

In addition to the presentation of workshops, efforts to collect basic energy data on Caribbean Basin countries in order to perform system analysis of appropriate energy alternatives were started and reported. The project went beyond the scope originally contemplated. It has stimulated technological interchange between educators and scientists in the region.

Region who were unknown to one another before. It received support from the Caribbean Development Bank which sponsored the participation of government technical planners in the workshop. In addition, a two-week training section on solar energy was sponsored by the Venezuelan government. Other activities generated by the project are discussed elsewhere in this report. A third workshop—on solar energy—is being planned for early 1983 and a proposal is being prepared to solicit funds to carry it out. The project was conceived by the Science and Technology Commission of UNICA, and the workshops were organized under the leadership of the Center for Energy and Environment Research (CER) of the University of Puerto Rico, in cooperation with the University of Miami and the University of the West Indies. The UNICA staff also collaborated at all times with the organizers. The ensuing substantive report and appendices summarize the major activities and accomplishments of the project.

PROJECT REPORT General The project to Develop Alternative Energy Science and Engineering in the Caribbean represents the first indispensable step towards a major coordinated program of technology transfer and adaptation to be undertaken as a cooperative effort by the universities and research institutes.

Of the region. Funding by the National Science Foundation allowed the planning, organizing, carrying out and reporting of two workshops—one on wind and the other on biomass—covering various aspects of the alternative energy problem. The Exxon Education Foundation, through the UNICA Foundation, also contributed in this part of the project. Later phases of the project involve the completion of research plans and proposals resulting from the workshops and data gathering in the region, the preparation of education and manpower training plans, and the compilation of reports on the alternative energy database and organization established. A proposal to fund the next phase, which includes a solar energy workshop in

1863, is being prepared. Publications 'The project has produced two technical papers (1) "The Energy Alternatives for the Caribbean" by J.A. Bonnet, IV., presented at a Workshop on Wind as an Energy Alternative for the Caribbean, Bridgetown, Barbados, December 7, 1981; (2) "Alternative Energy in the Caribbean" by H.P. Morrenstien, presented at the First Pan American Congress on Energy, San Juan, Puerto Rico, August 3, 1982. Dr. Bonnet is the Chairman of the Science and Technology Commission of UNICA and Principal Investigator of this project and Dr. Morrenstien is the Co-principal Investigator. The first paper, a copy of which is included as Appendix A to this report, discusses the energy situation in the Caribbean and outlines efforts underway to develop renewable energy alternatives in the region. This work is based on the author's experience in the region and on information received from UNICA contact persons.

The second paper, attached as Appendix B, gives further details about the planning and implementation of the project. Project Application Potential This project focused its efforts on the island communities of the Caribbean Basin. The islands have over eighteen (18) million inhabitants

in 42,213 square miles. It is estimated that 37,950,000 Bbls. of oil per year are imported by these islands. Table I summarizes geographic, demographic and other data on the Caribbean region. A list of renewable energy technologies which are deemed technologically suitable for the Caribbean, in rank order of estimated commercial readiness, is as follows:

1. Solar hot Co-generation
2. Hydroelectric
3. Electricity from solid waste
4. Small wind machines
5. Large wind machines
6. Electricity from bagasse
7. Solar ponds
8. Photovoltaics
9. Ocean thermal energy conversion
10. Geothermal energy conversion
11. Other

Morrenstien (Appendix B) computed the value of contribution in Bbls. of oil saved per year for each alternative energy technology at the end of full commercialization by the year 2000. This is

Presented in Table II, where it can be observed that the combined contribution from the listed sources totals 154,250,000 Bbls. of oil saved per year. Consequently, the region could theoretically become energy self-sufficient, as far as electrical generation is concerned. A plan of action or preparedness to move towards that goal is needed. From Table III, we can observe that wind and biomass (bagasse) show significant promise for making major contributions in the immediate future. Recognizing this condition, the UNICA Commission on Science and Technology selected these two energy sources for the first two workshops. In order to implement the project, this Commission requested from the universities and research institutes which are members of UNICA to appoint official contact persons knowledgeable in energy. These people would provide information on the energy state of affairs in their respective islands, participate in workshops, and serve as a focus to initiate educational and research activities in their institutions. Appendix C includes the names and addresses of UNICA Commissions on Science and Technology and contact persons. A questionnaire was circulated to all UNICA contact persons and the questionnaire was sent to ensure maximum response. Only five of the 18 contact persons answered the questionnaire. The others claimed the information about their islands was not readily available to them. This first experience reflected the reality of lack of information about renewable energy matters in the Caribbean. After a search of general and specialized libraries and other information centers in the Caribbean, it was found that the best data were at the Development Bank in Barbados, the Island Resources Foundation in Eastern Islands, and the Center for Energy and Environment Research in Puerto Rico. Table III summarizes the energy projects in the Caribbean region. Wind and biomass projects encompass the major efforts being pursued, which confirms our previous observation on the importance of these two.

Renewable energy sources for the region: The paper by Dr. Bonnet (Appendix A) was presented at the Wing Workshop in Barbados to the UNICA contact persons, who were requested to review it carefully and give their comments and suggestions. Only the representatives from Guyana and the Netherlands Antilles, along with the Caribbean Development Bank, submitted comments. These were incorporated into the final version of the paper. The other contact persons merely stated that

the paper reflected the current state of affairs in their islands.

The papers by Bonnet (Appendix A) and Harrenstien (Appendix B) present the most up-to-date general description of renewable alternative energy projects and potential in the Caribbean region, and in this sense, constitute major contributions to this project.

Workshop Summary 1. Wind as an Energy Alternative for the Caribbean Workshop:

The first UNICA workshop was carried out in Bridgetown, Barbados on December 6-8, 1961. Approximately 50 persons participated. The workshop program is included in Appendix D. The first part of the workshop consisted of background papers on wind energy. Particularly significant was the participation of Dr. I.S. Anderson, President of the USA Wind Energy Association, an organization which has keen interest in the Caribbean. Following the general presentations, the participants were divided into three workshop groups covering the following subjects: (1) Education and Training Needs (2) Research and Development Needs (3) Demonstration Needs

Each of the workshop session groups produced a report which is enclosed in Appendix D. It's interesting to note that the recommendations have similarities and that they focus on information needs and lack of human resources. A generalization and prioritization follows:

(1) A resource assessment of human and institutional capabilities, wind resources, and demonstration projects in the region is needed.

(2) After the first recommendation is implemented, detailed action plans and proposals should be developed.

The text should be corrected as follows:

Implementing the other workshop recommendations is needed. (3) Sources of funding to continue this project and to implement the most important recommendations should be sought. The group feels that if the above recommendations are implemented, the scientific and engineering capabilities of the universities and research institutes in the region will be greatly enhanced and strengthened in wind as an appropriate energy source for the Caribbean region. Appendix L includes the evaluation of the workshop made by the participants.

On Biomass Energy Alternative for the Caribbean:

The second workshop for UNICA contact persons was held in San Juan, Puerto Rico on April 28-29, 1982. The program of this workshop is enclosed in Appendix E. It is significant that the same UNICA contact persons who attended the wind workshop were also able to attend this workshop. The liaison initiated among UNICA contact persons facilitated the establishment of direct contact between some of the UNICA member institutions. This workshop was carried out immediately following the Seminar on Fuels and Feedstocks for Tropical Biomass, held in San Juan, Puerto Rico on April 26-27, 1982. Many of the UNICA contact persons were also able to attend this seminar, which provided them with a more thorough knowledge of biomass as an energy resource.

The biomass workshops indicated that the group feels that: (a) Research, development, and

demonstration projects in biomass as an energy source must be established in the Caribbean region. Funding to carry out such projects is critically needed. (b) Provision of training and education on Caribbean tropical biomass is a must. (c) UNICA should increase its information dissemination and technology transfer activities in the region. (d) The role of the UNICA Foundation to secure funds to implement the recommendations of workshops is very important. The Caribbean agricultural programs, especially in sugarcane and other food crops, are undergoing great economic stress. The possibility of reorientation is present.

To harness biomass for energy and food combined is an alternative that must be pursued immediately. This is one of the main reasons for recommendation number one. The group feels that the only reason this energy alternative is not being developed faster is lack of funding. The reports of the group sessions are enclosed in Appendix F. The evaluation of this workshop indicated that it was even more successful than the previous one. From the experience and recommendations made after the first (wind) workshop, changes in organization and strategies were made. The evaluation is enclosed in Appendix F.

CONCLUSION

It is clear that the Caribbean region is richly endowed with renewable alternative energy sources which could provide energy self-sufficiency to the region in the decades ahead. Two of the main sources--wind and biomass--have been studied and analyzed. Caribbean universities and research institutes should help in the development and utilization of these two energy sources. This is a pioneering effort occurring at a historical moment when there is a renewed interest in the "rediscovery" of the Caribbean region. This report should be useful to all funding and development agencies which are becoming aware of the region and willing to do something helpful based on solid ground. This effort is a very healthy seed, let us hope that somebody will water and nurture it for the benefit of the Caribbean community. It is also clear to the authors of this report and to the participants that at this stage a much more detailed resources assessment is needed before a realistic plan for education and training and research and development can be formulated. In this respect, the activities and accomplishments of this project represent important steps in the right direction.

CARIBBEAN DEMOGRAPHIC DATA TABLE 1.

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LIST OF APPENDICES

APPENDIX F: ENERGY ALTERNATIVES FOR THE CARIBBEAN
By Dr. Juan A. Bonnet, Jr.

ABSTRACT

Since all of the Caribbean countries except Trinidad and Tobago are petroleum importers, they have all been hurt by the dramatic increases in the price of petroleum during the last decade. Crude oil production has increased significantly in Latin America during the last three years, and the governments of Mexico and Venezuela are attempting to control oil sales in the Caribbean by offering incentives for energy conservation and the development of alternative sources. International agencies such as the World Bank and the United States Agency for International Development are now working with the

Caribbean Development Bank and CARICOM are working to develop alternative energy sources. There are many different energy sources that can be developed in the Region. Solar energy has received the most attention, but its use is still limited to crop drying, water purification, heating, and distillation. Hydropower is used extensively in Dominica, Haiti, and the Dominican Republic, and has great potential in other regions. The use of sugarcane and other fast-growing plants makes biomass a significant alternative. An experimental farm using the bioconversion of organic wastes is being operated successfully in Puerto Rico. Geothermal Power and ocean thermal energy conversion (OTEC) are two potential energy sources that are basic to Caribbean geography. Historically speaking, wind is one of the oldest sources of energy in the Caribbean, and preliminary studies have shown that several Caribbean islands could benefit greatly from this alternative. However, four environmental factors (noise, radio interference, air disturbance, and unsightliness) have to be addressed before wind energy becomes more widely accepted. Finally, in view of the perilous dependence on petroleum, conservation is also a potential energy transfer source.

INITIATIVES FOR THE CARIBBEAN By Dr. Juan A. Bonnet, Jr.

Good news for the developing countries from Geneva at the OPEC meeting in November 1982. The Organization of Petroleum Exporting Countries (OPEC) agreed to increase world oil prices to lead a barrel but also decided to freeze this basic price until December 1982, thus protecting poorer countries from unexpected and unmanageable price increases. However, unless long-range steps are taken soon, the OPEC action may not be permanent. Currently, 100 developing countries depend on oil to meet more than 60 percent of their energy needs. Most of them import four-fifths of their oil requirements. The price of oil, in inflation-adjusted terms, has quadrupled over the past decade, and many analysts predict price increases of 6 percent annually. This means that the poor countries are facing a significant financial burden.

"Countries now see an average of $100 billion a year for imports could be paying $110 billion a year by 119. To offset this economic drain, many countries are turning to the most widely available alternative supply. Forty percent of the developing world's timber reserves may literally go up in smoke as households and industry substitute firewood for oil. In a number of Caribbean countries, exploitation of wood resources is not in equilibrium with regeneration rates. Wood and charcoal meet a large part of Haiti's energy requirements and, to a lesser extent, those of countries with forest reserves, such as Belize, Dominican Republic, Grenada, Guyana, and St. Lucia. While developing countries contain two-thirds of the world's population, they account for only one-seventh of world energy production. The success that developing countries achieve in reducing their dependence on imported fuel will determine, in large measure, the degree of flexibility they will have in managing their economies in the future. Since the Arab oil embargo of 1974, the debt of developing countries has more than quadrupled to $455 billion, thus requiring more of their income to go for debt service at continuously increasing rates of interest. The World Bank estimates that up to 30 percent of the developing world's energy costs could be eliminated around 1980 by maximizing conservation efforts and by increasing energy production from fuel sources such as oil, gas, coal, hydropower, and renewables. It has outlined ways of reducing these energy costs by 18 percent without sacrificing economic growth during the coming decade. During 1981, there has been an increase in discussion about energy. In November 1981, South and North talked about energy at the Cancun, Mexico Summit. Moreover, in August, there were discussions about renewable energy at the United Nations Conference on New and Renewable Sources of Energy.

For months there have been discussions about a World Bank proposal to set up a separate energy affiliate within the Bank, but up to now, there has been no decision."

On the other hand, according to the Inter-American Development Bank (IDB), crude oil production is growing faster in Latin America than in any other region of the world. In its 1980 report on economic and social progress in Latin America, it stated that oil production in Latin America expanded by 20 percent and the region's share of the world oil production markedly rose from 7 percent in 1977 to 9.6 percent in 1980. That year, the total oil output of the region reached 2.222 billion barrels, an increase of 16 percent over 1979.

The rate of growth in production has been consistent since 1973 and compares favorably with the 5 percent increase in 1979. Combined production of Mexico and Venezuela accounted for fourteen percent of the region's crude oil production from 1975 to 1980, although Venezuela's share fell from 83 percent in 1978 to 32 percent. Conversely, Mexico's production rose from 18 percent of the region's output during the same period.

Concerning oil exportation, "the single most significant development during the past five years has been Mexico’s contribution to the region's increased rate of crude oil sales to external markets,” the IDB report stated. Mexican oil exports increased 118 percent in 1977, 99 percent in 1978, 88 percent in 1979, and 55 percent in 1980 when they totaled over 30 million barrels.

Production also expanded in Argentina, Brazil, Chile, Peru, and Guatemala, but it declined in Bolivia, and Trinidad and Tobago. The decline by 8 percent was a result of conservation measures enforced by the Government. The Mexican and Venezuelan governments are implementing an important oil agreement for the Caribbean. The New York Times reported that the Caribbean is being rediscovered again. The agreement stipulates 20,000 barrels for each country. According to it, part of the value of the crude purchased by the recipient country will be financed by the Venezuelan government.

Central Bank of Mexico. The loan will be given for five years at a preset rate of interest. However, if money is invested in development and preferably in energy, the loan will be extended for twenty years and the rate of interest will be lowered to 2 percent. A recently finalized agreement covers up to 20 agreements, with 2 being equivalent to 20. The World Bank has also called for an international research program to connect and broaden the use of renewable energy technologies in developing countries.

The bank, in a recent report, "Mobilizing Renewable Energy Policy in Developing Countries: Strengthening Local Capabilities and Research," particularly emphasizes the role of biomass in developing countries. It notes that in some countries up to 50 percent of energy consumption is derived from biomass. The report concludes that "present research efforts to improve biomass production are inadequate to begin to realize the enormous potential of this resource for the longer term. A well designed and funded biomass research program would improve the productivity of conventional species such as sugarcane, cassava, and sweet sorghum and identify species that are potentially more productive.

The research should be conducted in safety and agricultural laboratories located in developing countries." The second part of the World Bank proposal focuses on the development of

technologies for the production of energy from direct solar, wind, and biomass resources. Because a great deal of research to improve these technologies is already being done in the developed and in the more advanced developing countries, the program would be directed at assisting the less developed countries (LDCs) to assess and adapt new technologies for their own national programs.

The aim of such an international program would be to develop reliable data on renewable energy technology performance.

Evaluate experiences in different countries regarding the adoption of these technologies, and make global

Assessments of future technological developments and their implications for developing countries, the Latin America Plan for Action for the United Nations Conference on New and Renewable Sources of Energy recommended that priority be given to the following:

1. Regional Base Support
a. Energy planning
b. Information and dissemination
c. Training

2. Integral Regional Development
- Hydroelectric
- Firewood and charcoal,
- Vigour fuel production
- Solar energy,
- Vegetable residues

THE CARIBBEAN REGION

In the Caribbean region, the crude petroleum and refined products' share of total merchandise imports increased from less than 9 percent in 1971 to about 20 percent in 1980. Petroleum imports to the region increased during 1972-77 from $180 million to $620 million in 1980, since all Caribbean countries with the exception of Trinidad-Tobago are net importers of energy.

The Caribbean nations share several energy characteristics:

1) The subcritical size of most national energy systems precludes a choice of solutions.
2) There are no organized markets for indigenous fuels.
3) Indigenous fuels have not been able to replace the use of imported petroleum.
4) Commercially exploitable indigenous resources are limited.
5) There is a shortage of trained personnel to carry out energy assessments and develop alternative energy programs.
6) National governments resist considering regional cooperative efforts as the best way to approach energy problems.

In the Caribbean, a large amount of imported petroleum is used by the electric utility companies

which have peak capacities that range from less than ten megawatts to several hundred megawatts. (See Table 1 and Figures 1A and 1B).

The commercial sector demands for electric energy in the smaller islands are frequently dominated by the services industries (tourism and commerce), in some cases accounting for up to 50 percent of all the electric energy consumed in a country. Residential electric energy consumption accounts for approximately 20 percent. To solve the energy problems in the region, it will require concerted efforts and strategies.

In the Caribbean Region, the first fact that must be recognized is that there are large amounts of natural energy in the area which are not utilized. This situation arises from common geographical and ecological circumstances. The potential for renewable energy is only now being recognized, with countries exploring the possibilities offered by the region and the potential for non-conventional sources through research and demonstration. A consultant for the United Nations Development Programme (UNDP) recently concluded that hydro, geothermal, solar, and charcoal alternatives should be developed with priority in the Caribbean. This recommendation generally agrees with the report "Energy Resources in the ECLAC Member Countries". The Action Plan for the Caribbean Environment Programme calls for:

1) Assessment of major sources of non-conventional energy and their potential for utilization.

2) Management will involve:

a) Cooperation and technical assistance in the application of energy accounting systems which may be used as the basis for the formulation and implementation of sound national energy policies and programs.

b) Reinforcement of regional and subregional integrated non-conventional energy activities with the objective of a fuller exchange and dissemination of all available information and provision of training opportunities.

c) Development of a cooperative program for the implementation of appropriate technologies and practices for waste disposal with special attention to recycling, energy generation, and the special problems of the smaller islands.

The sources that are considered in the Action Plan are geothermal, solar, ocean thermal energy conversion, hydropower, biomass, bioconversion, and wind. It is important to mention that the United States Agency for International Development (USAID), in conjunction with the Caribbean Development Bank (CDB) and CARICOM, has been financing since 1979 a $7.6 million grant for energy development, including energy planning, assessment, design, testing, and dissemination of energy efficient technologies.

Alternative energy technologies. Based on the achievements of this exercise, feasibility studies will be prepared in support of further financial assistance from regional, multilateral, bilateral, and extraregional sources. USAID is in the process of formulating additional assistance projects totaling about $20 million for similar activities in the Dominican Republic, Guyana, and Jamaica, and for a follow-up project for the Caribbean region as a whole. Already a USAID loan of $7.5 million has been granted to help Jamaica establish an energy program. The goal is to strengthen the island

nation's ability to develop and carry out urban energy conservation programs and develop alternative energy.

Notwithstanding these positive signs of interest and action on aspects of the Caribbean energy question, it may be observed that President Ronald Reagan's Caribbean Basin Initiative proposal did not make significant mention of energy issues, even though Puerto Rico has proposed that the Center for Energy Research of the University of Puerto Rico become the research center on energy in the Caribbean. CEER's twenty-five years of dealing with energy, the last five specifically on alternative and renewable energies, are a valuable platform from which many problems may be identified and solved. An encouraging sign may be recent indications of awareness that the CBI will impact existing energy use patterns within the Caribbean. This may lead to increasing awareness of the need to confront the energy question, non-renewable but more importantly renewable, in the Caribbean more comprehensively.

Geothermal Power: The entire Caribbean Region is part of the Caribbean Tectonic Plate which occupies most of the Venezuela and Colombia basins and moves east relative to both the North American Plate on its northern edge, and the South American Plate on the south. The entire area appears to have been extensively intruded by large bodies of basaltic magma which developed deep within the mantle of the Earth and moved upwards.

Upward. Active volcanism around the margins of the sea and constant seismic disturbances result in continuous readjustments of the crust. Regions of geothermal reservoirs are generally located along the margins of major crustal or tectonic plates; the Lesser Antilles is recognized as one of these zones. A tremendous waste of energy in these areas comes from volcanic eruptions, with large amounts of hot (700°C to 1300°C) magma from the mantle being expelled through the crust (See figure 3). Volcanoes exist in the Lesser Antilles. Martinique has the presently inactive Mont Pelee. In Guadeloupe, a vein of steam connecting with La Soufriere volcano has been tapped by drilling at Gourbeyre off the west coast. This drilling has been capped and, because the pressure is sufficient to operate a geothermal electricity generating station, the necessary plant and equipment has been ordered. Reports of potential geothermal energy resources in Dominica, Montserrat, St. Lucia, St. Vincent, Dominican Republic, Grenada, Haiti, and Jamaica have been published. St. Lucia is already planning to develop its thermal source of power at Soufriere with 1 to 5 megawatt units. In 1969, a United Nations' study was done in Dominica where the extensive surface manifestations make the geothermal potential quite apparent. In regard to Haiti and Grenada, it will be necessary to determine the origin of the hot springs to learn whether they are geochemical or geothermal before any exploratory drilling can be attempted. A feasibility study of geothermal potential is currently underway for generation of electricity in the Dominican Republic. Geothermal energy has some environmental disadvantages because gases such as methane and traces of hydrogen sulfide are capable of polluting the atmosphere. However, this problem can be minimized with the appropriate resources. It is worth emphasizing that as of today, few zones have made efforts at the utilization of geothermal energy for power, and more efforts have been made in the state of... [continued text]

California's new metric and Contra America. An alternative source of energy has received the greatest attention. Essentially, all our energy, except nuclear and geothermal, is derived directly or indirectly from the sun. The solar radiation in the Caribbean Region is of the order of two thousand kilowatt-hours per square meter per year. Average air temperature varies from 70°F in February to 83°F in September. Nearly fifteen times more solar radiation reaches the earth's surface than the

total consumption of commercial energy. Presently, solar energy is used on a very limited scale in the Caribbean for crop drying, water purification, heating, and distillation of sea water. Several facilities have been built by foreign research institutes: one in Haiti and one in St. Vincent in the eastern Caribbean. These facilities have proved to be useful to small rural communities. Solar nutmegs in Grenada, chili peppers in the application of solar energy for generating have reached satisfactory levels of development in Jamaica, Barbados, and Puerto Rico. A survey undertaken in January 1982 by CEER, in conjunction with the Puerto Rico Department of Labor and Human Resources, indicated that there were approximately 18,000 residential hot water heaters in use. The development of solar industrial steam generators and solar air conditioner units are being pursued by the Center for Energy and Environmental Research (CEER) of the University of Puerto Rico. A 1,100 square meter solar air-conditioned factory in Canovanes, Puerto Rico, and a new 400 square meter solar air-conditioned Post Office in Guayana, Puerto Rico, are examples of commercial installations. In Lagos del Norte, a 203-apartment condominium in Puerto Rico, 3860 sq. Ft. of solar collectors were installed, with a 2500 gallon hot water tank to supply the needs of more than 1000 residents of the building. In 1981 a detailed design for a solar energy system to provide 210°F hot water at the Nestle-Libby food processing plant at Santa Isabel, Puerto Rico was completed.

The active area of 0,400 sq.ft. Detailed system simulation studies predicted the solar array would provide 100 ETU/year to three different processes including pasteurization, sanitation, and boiler preheat. This represents an annual saving of approximately 102,000 gallons of no.6 fuel oil. The generator is designed to use hot water to reclaim refrigerant to sustain.

Technologies have been built, showing promise of great. The Dominican Republic and the Caribbean island of Antigua are of natural salt-gradient ponds and are presently being considered for energy storage. In Barbados, passive solar designs have been used. An example is the Tech Farm Energy Unit. Cataloging of the Caribbean Development Bank's passive system progress is also underway. Solar air conditioning studies and tests are being conducted in the new Barbados Government and the Latin American Organization for Energy.

The design and fabrication of a solar system had a total cost of $5.2 million. The largest solar hot water system in the Caribbean opened in September at the Cornwall Regional Hospital in Dominica. The project was sponsored by the Citizens Energy Corporation. The Caribbean has almost everything in its favor to make solar industrial energy a success. It has an outstanding availability of direct, constant sunlight; an increasing well-documented insolation data base; a well-established tourist industry which requires air conditioning; a well-established petrochemical industry in places like Trinidad, Curacao, the Virgin Islands, and Puerto Rico.

The fabrication of inexpensive collectors by unskilled labor for hot water heaters is already being done on many of the islands. In Puerto Rico, a Plexiglas solar concentrator collector for air conditioning systems has been developed and is being fabricated.

CF power generation in Dominica and 27 CERECUK in Surinam and Dominican Republic. It could also play an important role in Ajanor Armen and Jebaice. In Guyana, hydro potential of from 71000 to 7000 energy units has been identified, and in Surinam a hydropower potential of several regents

exists. Belize is interested in mini hydro projects. A Colesbie Street team is providing technical assistance to Haiti and Dominica in order to develop small-scale hydroelectric resources. The Centro de Garioty in Mysore, Colombia has developed some mini hydro technologies suitable for the biomass. Broadly defined, biomass consists of terrestrial and aquatic vegetation and its residues and wastes, including animal wastes. Biomass is essentially a viable and indirect form of solar energy - sunlight powering the chemical reaction which converts CO2 and water into solid green matter and oxygen. The sub-tropical climate of the Caribbean is ideal for biomass and has been recognized for its abundance in producing a major form of biomass in the past, i.e., sugar cane. Sugarcane is grown in many of the Caribbean countries and in large quantities in Barbados, Cuba, Dominican Republic, Guyana, Haiti, Jamaica, Puerto Rico, St. Kitts-Nevis, Anguilla, Trinidad and Tobago. Sugar factories in these areas are able to satisfy all their energy requirements from bagasse, and in Barbados, 20 percent of their energy requirements. Considerable use is made of bagasse as fuel for sugar mills in Guyana, Puerto Rico, and other countries. Firewood, charcoal, and bagasse provide an estimated 90 percent of all primary energy supplies in Haiti. The energy content of dry bagasse is about 5.15 kilowatt hours per kilogram. An extensive program of more than $1.60 million for the development of renewable energy using tropical grasses for energy use has been going on since 1978 at the EER in cooperation with the Agricultural Experimental Station. In this program, the alternative use of sugarcane to produce both bagasse and the manufacturing of molasses and alcohol has been pursued; also the optimization.

The study of tropical grasses for biomass production states, "A short stack of trim biomass (62% moisture) contains about 15 million BTUs of energy." This is equivalent to two 42-gallon barrels of residual fuel oil. A significant amount of sugar and high-test molasses are also produced. According to CEER scientists, it is estimated that 70,000 acres planted with energy cane could potentially double current sugar production.

This could eliminate Puerto Rico's rum industry's reliance on imported molasses and reduce Puerto Rico's petroleum imports by 72%. The costs are estimated to be about $1,000 to $3,000 per acre, with potential yields of fiber and molasses. Despite inflation and high costs, it is currently possible to plant energy cane and produce it at less than $2.00 per million BTU.

Puerto Rico is geographically and historically positioned to embark on a bioenergy industry. Located around 12 degrees north latitude, its tropical climate can support year-round plant growth. Temperatures rarely drop below 60°F. There are thousands of plant species, both woody and herbaceous, that can utilize this climate for continuous growth processes.

Approximately 80% of the land is humid and receives abundant rainfall. Irrigation is well developed in the remaining arid regions. There are six distinct ecological life zones. The lands offer a varied selection for both research and commercial development. Puerto Rican soils include 9 orders, 27 suborders, 27 great groups, 54 families, and 163 series. It represents nearly all of the Caribbean in its variety.

Biogas is produced when organic wastes, manure, vegetable matter, or human waste are decomposed by bacterial action in anaerobic conditions, like those found in an airtight digester. The biogas produced has a composition of approximately 58 to 65 percent methane (CH4).

The text contains 35 to 45 percent carbon dioxide (CO2), and traces of oxygen, nitrogen, and

hydrogen sulphide. It combusts like a calorific value of 20,000 to 26,000 Kilo Joules per cubic meter gas. It can be used for cooking, heating, and refrigeration. Once the gas production has ceased in the digester, the residue forms an excellent fertilizer which can be used to grow algae, and the liquid can be extracted for irrigation. A pig farm is being operated successfully by private enterprise in the south of Puerto Rico. All of the electricity at the farm comes from local biogas production, and also algae is grown as a feed supplement for the pigs. 2.5 cubic meters of biogas per day, roughly equivalent to one-third of a gallon of gasoline. It has been estimated that waste from one thousand poultry broilers will be capable of producing about 10 cubic meters of methane per day, energy equivalent to one hundred kilowatt-hours per day. If one assumes 30 million broilers, the energy potential equivalent to the methane produced will be 3 million kilowatt-hours per day. Jamaica currently has one unit generating methane from animal wastes and has requested $3.75 million from Kuwait and Iran for 2 biogas demonstration units. Barbados has set up three biogas digesters. Puerto Rico is preparing an energy-integrated farm on the semi-arid South Coast. The farm has a current base of 400 registered Holsteins, to be increased to 500 during 1982. The farm's 1982 average power demand will be about 1,680 Kw/day, and 24.6 tons of raw manure will be produced daily. The proposed energy integration system has two functions: (a) to produce green feed, electricity, and fuel substitutes from manure, and (b) to establish a waste system in compliance with Puerto Rico's environmental quality. The proposed energy-integration complex consists of eight subsystems. These include components for manure collection and blending, a gas generation system, a solids dehydration and drying subsystem, and a subsystem for wastewater cleaning and treatment.

Including a monitoring subsystem 45, a significant 30 to 60 percent of dairy feed requirements is provided by the integrated corporation that has installed a 3.5 distillery residue. Disposal of municipal wastes becomes an increasingly serious problem each year because of continuing urbanization. It may be possible for municipal waste to make a substantial contribution to solving both the energy and waste problems by converting it into biogas for energy use. San Juan, the capital of Puerto Rico, has been investigating the methane conversion of its present landfill.

The northeast trade winds prevail over the Caribbean Sea, blowing mostly from the east or northeast more than 70 percent of the time at velocities of about 10 miles per hour. Because of these favorable conditions, a wind power generator was installed by the U.S. Department of Energy on the island of Culebra in Puerto Rico. This energy generator produced 584,980 kWh of energy from 1976 to 1981, despite some issues to improve blade performance and the occurrence of strong winds.

The project is being continued, however, a salient finding is the need to involve the community in such projects. In Culebra, although residents favored wind energy as an alternative, their perception of the project and its performance was largely negative, due to lack of participation and preparation.

Several of the Caribbean Islands show great suitability for the utilization of wind energy. The Caribbean has had a long experience in using wind as a source of energy. Boats have been powered by wind for a long time, and wind has been used in the production of machinery for crushing sugarcane. Small factories are often strategically elevated on land to use the available wind for driving gears to crush the cane. This is true for Jamaica, Antigua, and Puerto Rico. In Antigua, the Rockefeller Foundation has implemented a wind energy project.

A proposal for two pilot wind generators (56 Kilowatt each) has been sent to the United Nations Interim Fund. The renowned Caribbean Meteorological Institute is an active participant in collecting information about wind speeds in the Caribbean Region.

A Wind Solnate Corporation has been installed in Puerto Rico by the Future Energy Resources Corporation. Because of its importance, some comments about the environmental effects of windmills are significant. The impact of wind turbines on the environment can be generally classified into four main areas.

The effect of large wind turbine generators is about 1 percent of the size, increasing the noise level. Reducing this solves the problem. Therefore, there should be an understanding of acceptable noise levels for these environmental computer programs to predict the wind generators.

Future speed improvements need to be designed to reduce these effects. The rotation of wind turbine blades can produce a frequency that may interfere with TV receptions. There are various solutions to this problem, depending on the local landscape and reduction of wind power in nearby private properties.

The wind pattern is altered by the presence of wind turbines. At optimal operating conditions of the turbine, the effect can be felt up to a distance of the machine rotor's radius, causing a disturbance to the blades. For a 400% average, this can be felt for a distance of 4500 ft.

The objectionable sight of wind turbines appears to be insignificant when compared to other energy sources. Consequently, more than 100 United States electric utilities are considering wind projects. Southern California Edison is already testing wind machines in the San Gorgonio Pass and has signed agreements to purchase as much as 85 megawatts from 50 wind turbines.

Hawaii has signed a contract with Wind Farms, Inc. to install 20 turbines on Oahu by 2035. Wind Farms, Inc. has persuaded Pacific Gas & Electric Co. to buy as much as 350 megawatts of wind power.

Three 2.5 Megawatt wind turbines (HC0-2) are operating at Goodnoe.

Hill and Heshington from the Bonneville Power Administration, with turbine blades 400 feet long and towers 200 feet tall, and the blades rotating at 17 RPM, are engineering and constructing a GroWind (Grosse Wind Energie) 3-megawatt wind energy machine. Wind appears as one of the most promising energy alternatives for the Caribbean Region. Coastal winds could be significant for meeting local energy demands and thereby reducing investment requirements for transmission and transport of electricity and fuels.

CONCLUSIONS

This paper briefly discussed the renewable energy technologies - geothermal, solar, OTEC, hydro, biomass, bioconversion and wind, which have the largest potential for the Caribbean Region. But let us not forget that any activity of man causes some kind of impact on the surroundings. The aim of developing renewable energy technologies is to look for socially desirable, economically viable, and ecologically prudent man-made production systems, paradigmatically inspired by the ecosystem concept, and capable of jointly supplying human necessities.

Environment, in this perspective, is a resource potential to be harnessed basis and, as such, an ecologically sound development approach for renewable energies utilization including wind power is more suitable. Caribbean renewable energy development and its effects are summarized in Table 2. It is important that these renewable energies be examined thoroughly.

Liquid transport fuels, for instance, can be a significant part of the energy mix. These are outlined in the section on "Energies and Applications." Renewable sources of technologies, mini-hydro, small-scale, and available for rapid growth and a force of energy, United Nations new and renewable, solar, and biomethanation are already available for implementation in a modern mode. They can all be used in the Caribbean Region. Table 4 presents demonstration projects in renewable energies throughout the Caribbean Region. More details of some of these projects are given in the Energy Resource member countries report. Large-scale hydro projects are also considered.

Geothermal and ocean power will continue to play a central role in new networks that principally benefit urban areas. There are considerable interests in non-conventional technologies such as peat that are used for food production. Due to their expected applications, energy systems for technologies for water pumping, low-temperature heating, cooking, crop drying, and power generation are available and are expected to play a significant role in the near future.

Small and medium-sized windmills used in a decentralized mode are already cost-competitive in many areas, and medium and large windmills are expected to be attractive enough for autonomous and integrated modes of operation in windy areas such as the Caribbean. For given promising areas, it is important to determine the wind potential and how soon wind will become economically competitive.

Other new and renewable energy technologies such as ocean thermal energy conversion, geothermal energy, large-scale solar ponds, tar sands, and oil shales are all very promising. With suitable support for research, development, and demonstration, these resources could emerge as significant options within short to medium time frames.

Although this paper's concern is with alternate and renewable energies for the Caribbean, I cannot end without pointing out that there is also another source of energy - conservation. A recent study at CEER shows that in Puerto Rico, transportation used up 28% of all energy created by petroleum, on which it is nearly totally dependent, and 83% of that was accounted for by private passenger vehicles, two-thirds of which were in urban traffic. Much of this is wasteful, remediable by relatively few "fixes" - engineering and administrative.

Significantly, the report finds that in the area of transportation, alternative fuels would create only a fractional difference, all the more reason for increasing efforts to create alternate and renewable energies for essential needs.

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FIG 1-A 1-8 ELECTRICITY CAPACITY AND PRODUCTION PER CAPITA IN SOME ISLANDS AND COUNTRIES IN THE CARIBBEAN Figure 1a.

PLATE BOUNDARIES OF THE CARIBBEAN REGION

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Jurisdictions are blessed with an abundance of inexhaustible natural sources of energy, including solar, thermal, wind, ocean, biomass, and in certain locations, large amounts of geothermal energy. This paper reports on the progress of a project which is currently underway to develop the scientific and engineering capabilities of the universities in the Caribbean region in areas of alternative energy, under funding provided by the National Science Foundation, the Exxon Educational Foundation, the Caribbean Development Bank, and the Government of Venezuela. The project uses unique methods and resources. The mechanism of the network of the Association of Caribbean Universities and Research Institutes (UNICA) is utilized to endorse a cooperative research effort aimed at increasing the capacity of institutions to assist in the introduction of alternative energy solutions into the region. An element of data collection and systems analysis of appropriate energy technology alternatives is included, with results culminating in the preparation of cooperative research and training programs to assist in the early implementation of the most economically viable alternatives. The research workshop format has been used and provisions have been made for the active involvement of a representative network of regional research centers. With coordination and leadership being provided by the Center for Energy and Environment Research (CEER) of the University of Puerto Rico, the University of Miami, the

Central University of Venezuela, the University of the West Indies, and the University of Florida are all taking active roles in the assurance of the success of this activity.

ALTERNATIVE ENERGY IN THE CARIBBEAN

Howard P. Barren

Introduction

This paper reports on the progress of an ongoing project to develop the scientific and engineering capabilities of the universities and institutes in the Caribbean, in order that faculty, students and staff at these institutions may assist in the orderly development of a "grass-roots" conversion to the region during the

Decades ahead, the project is funded primarily by the National Science Foundation, under their Science in Developing Countries program, and by the Exxon Educational Foundation. Additional invaluable assistance has been provided by the Caribbean Bank (CDB), and by the Venezuelan Government in developing alternative energy sources.

BACKGROUND AND CONTEXT

Figure 1 shows an archipelago with a total land area of about 90,000 square miles, encompassing most of the 51 inhabited islands of the Caribbean and with a total population of approximately 20 million. Only one of these island-states produces fossil fuels, Trinidad, which has 1/45th of the total land area and 1/20th of the total population. The size of its foreign exchange reserves places it among the first six of all the nations in the British Commonwealth. The other 50 island-communities depend on imported fossil fuels for 99% of their energy needs.

The Caribbean community includes the collection of geographical entities which occur in the vicinity of the Caribbean Sea. This sea is part of the Atlantic Ocean lying directly east of Central America; north of Panama, Colombia, and Venezuela; west of the Lesser Antilles (Leeward and Windward Islands and others) and south of Cuba, Hispaniola and Puerto Rico. The sea is about 1500 miles long, 700 miles wide, and as deep as 22,788 feet. Ships which use the Panama Canal must, by necessity, pass through the Caribbean Sea, and as a result, pass close to many of the Caribbean islands.

According to Adolf A. Berle, former Assistant Secretary of State for Latin America, the Caribbean is "the most strategically placed, densely populated, ethnically complex and politically divided archipelago on earth." Since the 1950s, the Caribbean has made strenuous efforts to diversify its economy by providing more jobs through industrialization and by expanding tourism. As in so many developing countries throughout the world, these early efforts were almost totally based on the use of imported fuels.

The text is quite garbled and difficult to interpret, but I'll do my best to correct grammatical errors and make the passage more comprehensible.

"Decades ahead, most of the archipelago will be a disaster area unless dependence on imported fossil fuels is reduced and the use of alternative sources of energy is greatly increased. Progress is

blocked due to (a) lack of power, (b) inadequate research technology and (c) social disruptions. Four major issues are the use of existing technology, adaptation or modification of various technologies to fit the environment, (d) the lack of a grassroots cooperative energy program involving universities and research institutes of the region, and (e) the lack of investment capital.

A system of cooperation is essential in a region whose history has been one of fragmentation and dependence on external markets and authorities. The project must provide for, and depend upon, active cooperation from Spanish-speaking, English-speaking, French-speaking, and Dutch-speaking Caribbean universities and research institutes.

The levels of research work will vary, requiring advanced centers to provide technical assistance to those which are less advanced. This way, the effort to find viable programs for alternative energy sources can be shared by all involved institutions. Its long history of elitism and dependence on external rulers has left a bitter legacy of resentment among many Caribbean people.

Even hatred persists. The ideation of conflicts and evidence of abuse are apparent, just as the people from Cuba and Malta and the large migration into Puerto Rico from the Dominican Republic. Aid from external sources is important, but it cannot alone resolve issues of growing poverty and discontent. Ultimately, it depends on the people to analyze their problems and find solutions.

Cooperative relationships between individual United States and Caribbean universities, although valuable, do not fully meet the need for more comprehensive partnerships. This is why the project attempts to form relationships between all involved researchers and scientists."

The text is about a network of Caribbean institutions that provide private centers within the region. These centers aim to enhance research programs and preparation for a comprehensive regional program using alternative sources of energy. Through these methods, it is anticipated that the quality of science and engineering research will improve, realizing the potential for intellectual stimulation, technology transfer, and further cooperative efforts.

The Caribbean community possesses a rich potential in inexhaustible alternative energy sources. In addition to geothermal energy, which is abundant in locations such as St. Lucia, there are many other feasible P-related alternative energy sources. This is largely due to the Caribbean's latitudinal range of 10°N to 25°N, resulting in year-round solar insulation of approximately 2000 BTU per square foot per day, which is about twice as much as in Washington, D.C. Some of the common solar-related resources include trade winds, ocean waves, moderate ocean currents, extensive ocean thermal masses, year-round biomass production, agriculture, mariculture, and various forms of solar thermal and solar electric options.

This project focuses on the need for practically all the countries of the Caribbean archipelago and Guyana to achieve greater energy self-sufficiency. It emphasizes the role that Caribbean universities and research institutes can play in meeting that need, and the fact that the region has a rich potential in inexhaustible resources. We believe this project represents a first indispensable step in using the existing network of research centers, schools of natural sciences and engineering, and other related university departments in a coordinated program to help meet the region's energy needs.

Furthermore, it highlights the concept of the region as a laboratory for the development of alternative energy sources, from which lessons can be learned and demonstrations carried out that will benefit other countries. This opens an exciting concept of energy sources.

Due to the urgency of the energy situation in the Caribbean, it is crucial for the economic and cultural development of the region that a degree of energy self-sufficiency is developed at an early date. If this does not occur, disastrous consequences will result as the prices of imported fuel escalate beyond the reach of all but the most well-endowed (or most heavily subsidized) communities. This could force them into either a complete dependence on those who have oil, or into a position of deep poverty, beyond which economic and political survival may become impossible.

On this order, UNICA AND THE UNICA FOUNDATION, INC. are stepping in. The organization under which this project is being conducted is UNICA, supported by the UNICA Foundation, Inc. The principal investigator, Dr. Juan A. Bonnet, Jr., Director of the Center for Energy and Environment Research at the University of Puerto Rico, and the Co-Principal Investigator, Dr. Howard Harrenstien, Director of Architectural Engineering at the University of Miami, are both members of the UNICA Commission for Science and Technology, with Dr. Bonnet as Chairman.

In the late 1960s, perceptible Caribbean educators saw the future development of the Caribbean community as a matter of common regional concern. To meet their common needs, they created UNICA, a voluntary association of Caribbean universities and research institutes dedicated to positive, carefully-directed efforts for Caribbean development. Founded in 1966 by 16 universities located in ten Caribbean countries, the organization now has 43 members representing a constituency of more than 300,000 students and 39,000 faculty.

To lend assistance and impetus to the goals of UNICA, the Foundation of Caribbean Universities and Research Institutes Inc, was created. With Dr. Henry King Stanford, from the University of Miami, as President, the Foundation is a non-profit organization in Florida. It has tax-exempt status as a public charity by the Internal Revenue Service and support to the Foundation is tax-deductible under the law.

The Internal Revenue Code is significant as it provides for alternative sources of energy and the improvement of university teaching and research in the Caribbean. These are among the objectives of this organization, and there is agreement to support this project. The organization, established as "2", was the first to assess demographic and statistical data for most of the island communities involved in the Caribbean region. This information is contained in Table 1.

Table 1 presents data on language spoken, latitude, longitude, area, population, population density, highest point, length, width, lateral exposure to wind, kWh per person per year electrical consumption, and millions of barrels of oil per year required to generate electricity. This table is preliminary in nature and should not be overestimated in terms of its accuracy. Its purpose is only to allow preliminary assessments to be made.

However, it is hoped that this data will be found useful to those who would engage in energy analyses and projections. The author intends to continually update and expand on this data.

Therefore, people who have additional or conflicting information are urged to contact him.

Table 1 estimates a total population among all the islands mentioned to be 15,196,800. This figure is probably somewhat low, as 1970 statistics were used for some of the islands. The combined area of all islands is 42,213 square miles, and the estimate of combined projected shoreline, which is normal to the prevailing trade winds, is significant.

It's estimated that 87,950,000 barrels of oil per year are imported by these islands collectively to provide electrical energy to their population. If the influence of Puerto Rico is subtracted from these totals, they become 14,861,800 persons, 26,778 square miles, 787 miles, and 16,078,000 barrels of oil per year respectively.

Earlier in this conference, in the paper by Ronald D. Scott and Howard Harrenstien, a rank-ordered list of alternative energy technologies was discussed.

Technologies that were deemed technologically suitable for development in Puerto Rico were presented. If this list is reviewed for possible application to the remaining islands in the Caribbean, only slight modifications and additions need be made. The resulting list, in rank order of estimated readiness of the technology, is the following:

1. Solar Hot Water
2. Co-generation Hydroelectric Electricity from Solid
3. Small Wind Machines

4. Large Wind Machines
5. Vineyards
6. Electricity from Bagasse
7. Electricity from Solar Ponds
8. Photovoltaics
9. Ocean Thermal Energy
10. Geothermal Energy Conversion
11. Other

A preliminary estimate of the potential of these technologies as far as replacement of imported fossil fuels is concerned may be produced by assuming that the islands in the Caribbean have many similarities of character, and that lifestyles will eventually reach similar levels of industrialization and development. One can then take the current estimates of potential for Puerto Rico and use them in predicting the potential for the remaining islands in the Caribbean.

Table 2 computes the values of contribution in barrels of oil saved per year for each alternative energy technology at the end of full commercialization by the year 2000, using data which is consistent with that presented in the Scott-Harrenstein paper of reference. It may be observed that the combined contribution from the sources listed totals 154,230,000 barrels of oil per year saved. This assumes that the energy produced by the alternatives replaces electrical energy which has been produced by burning imported fossil fuel at 30% efficiency of conversion.

From Table 1, subtracting the contribution from Puerto Rico, the region imports only 16,078,000

barrels of oil at the present time. If a 5% per year growth rate is assumed from 1980 to the year 2000, this total would grow to 42,662,374 barrels of oil per year. Energy self-sufficiency, then, as far as electrical generation is concerned, is achievable by the year 2000 if the case continues to be so.

27.66% of the total potential provided by alternative sources is estimated in Table 2. Precisely 42,660,018 is 27.66% of 154,230,000.

This is excellent news for this region. However, a plan for orderly development and progress must be instigated at the earliest opportunity; delay would result in losing vital capital necessary for the transition. This capital should not be wasted on escalating imported oil purchases, or the goal of energy self-sufficiency might become unachievable. As observed in Table 2, Wind (Numbers 5 and 6) and Biomass (Number 7) show significant promise for making major contributions in the near future. Recognizing this potential, the UNICA Commission for Science and Technology selected these for early emphasis. A progress report on the result of this activity is contained in the following section.

The UNICA project reported here has, to date, focused its activities on gathering material related to the current state of affairs in the Caribbean with respect to alternative energy education, training, research, development, and demonstration. To collect this material and impact the planning process for the acceleration of introducing alternatives into the region, it was decided to ask the universities and research institutes which comprise UNICA to appoint official contact persons who could represent their institutions, and who could participate in workshops designed to stimulate the production of relevant material on the chosen subjects.

1. Wind Workshop

The first opportunity for the contact persons and other invited participants to convene was in Barbados from December 6-8, 1981. A workshop titled "Wind as an Energy Alternative for the Caribbean" was presented at that time. Approximately 50 persons participated. After hearing background papers on the subject, the participants divided into three workshops covering the following subjects:

Education Moderator and Training - Dr. Howard Harrenstien, Research and Development - Dr. Edwin Nuflez, Demonstration Moderator - Dr. Modesto Iriarte. It is the opinion of UNICA that the December 6-9, 1981, Barbados Conference on Wind as an Energy Alternative for the Caribbean was a success, when seen from the point of view of evaluation by the participants, and from the point of view of providing an opening in communication links on wind energy in the Caribbean scientific and engineering education and research community. Although the three culminating workshops were conducted independently from one another, recommendations produced by them had some marked similarities and focus. A generalization of the recommendations and a prioritization results in the following conceptual overall recommendations:

1. A resource assessment should be conducted to determine the existing situation in education and training, manpower, the magnitude of the available wind resource, the availability of appropriate wind sites, and the existence of wind demonstration projects in the region.

2. Based on the results of the current “state of the art” assessment in priority #1, a plan should be prepared which would detail the steps (including costs) necessary to accomplish an acceptable level of progress toward achievement of the rest of the recommendations from the individual workshops.

3. Source of funding should be identified which will enable the continuance of the program which was initiated by this conference and which will ensure the timely completion of priorities 1 and 2. With the achievement of these three priorities as objectives, it is predicted that the scientific and engineering capabilities of the universities and research institutes in the region will be greatly enhanced and strengthened, as far as this form of alternative energy is concerned.

The draft of the proceedings of the Barbados Wind Workshop has been prepared, and copies may be obtained by writing to: Asociación de Universidades.

Caribbean Institutes Postal Address 11532 Coparra Heights Station San Juan, Puerto Rico 00922. Thomas Mathews, Secretary General.

2. Biomass Workshop

The second opportunity for the UNICA contact persons to convene and discuss the alternative energy situation in the Caribbean was in San Juan on April 28-29, 1952. The subject was "Biomass as an Energy Alternative for the Caribbean". The proceedings for this workshop are in the process of being prepared. Once completed, they may be obtained from Dr. Mathews, at the above source. In the interim, copies of some of the papers presented may be obtained directly from:

Dr. Juan A. Bonnet, Jr., Director
Center for Energy and Environment Research
GPO Box 3682
San Juan, Puerto Rico 00936

The papers which are immediately available are listed after the reference section of this paper.

VII. SUMMARY

Energy consumption patterns for the Caribbean and alternative energy assessments and analyses are a continuing activity by the research staff. Results of some of the early assessments were compiled by Dr. Bonnet, and may be obtained from him at the address indicated on the preceding page. It is clear at this stage that a much more detailed resources assessment is needed before a realistic plan for education, training, and institutional development can be prepared. In fact, it may be that through the involvement of persons in the Caribbean in the assessments and plan development, a substantial level of institutional development will occur by virtue of the grassroots nature of the activity.

What is equally clear, however, is that the Caribbean region is richly blessed with renewable alternative energy sources which are quite capable of providing energy self-sufficiency to the region in the coming decades. Whether they do or whether they don't is a matter for responsible citizens,

both within and outside the region, to immediately face. The conversion to alternative energy sources will not happen without major human and institutional effort.

The least of which is related to education, training, research, development, and demonstration.

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MEAN DEMOGRAPHIC DATA

Apologies, the following text seems to be in an unrecognizable format and cannot be corrected.

APPENDIX: MEMBERS OF UNICA SCIENCE AND TECHNOLOGY COMMISSION

UNICA SCIENCE AND TECHNOLOGY COMMISSION CONTACT PERSONS

APPENDIX: MEMBERS OF UNICA SCIENCE AND TECHNOLOGY COMMISSION

Mr. A. Bonnet, Chairman, Center for Energy and Environment Research, University of Puerto Rico, GPO Box 3662, San Juan, Puerto Rico 00936

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APPENDIX D
Report on Wind as an Energy Alternative for the Caribbean Workshop
Barbados, December 6-9, 1981
UNICA Commission on Science and Technology

APPENDIX D-1
WIND AS AN ENERGY ALTERNATIVE FOR THE CARIBBEAN WORKSHOP SUMMARY REPORT

It is the opinion of the UNICA Science and Technology Commission that the Dec. 6-9, 1981 Barbados Workshop on Wind as an Energy Alternative for the Caribbean was a success, when viewed from the point of evaluation by the participants, and from the point of view of providing an open line of communication on wind energy in the Caribbean scientific and engineering educational and research community. Although the three culminating workshops were conducted independently from one another, recommendations produced by them had some marked similarities and focus. All three reports are included here. A generalization of the recommendations and a prioritization results in the following conceptual overall recommendations.

1. A resource assessment should be conducted to determine the existing situation in education and training, manpower, the magnitude of the available wind resource, the availability of appropriate wind sites, and the existence of wind demonstration projects in the region.

2. Based on the results of the current "state of the art" assessment in priority 1, a plan should be prepared which would detail the steps (including costs) necessary to accomplish.

An acceptable level of progress toward the achievement of the rest of the recommendations from the individual workshops is expected. Thirdly, sources of funding should be identified by the UNICA Foundation. This will enable the UNICA Commission on Science and Technology to continue the program which was initiated by this conference, and which will assure the timely completion of priorities 1 and 2.

With the achievement of these three priorities as objectives, it is predicted that the scientific and engineering capabilities of the universities and research institutes in the region will be greatly enhanced and strengthened, as far as this form of alternative energy is concerned. The UNICA Science and Technology Commission stands ready to assist as a mechanism through which the above may be accomplished, and by which UNICA member institutions may better serve the communities in which they are located for the overall betterment and improvement of the entire region in this "grassroots" type of Caribbean development initiative. As a Commission, we are

deeply grateful for the generous support which has been given by the National Science Foundation, the Exxon Prevention Foundation, the UNICA Foundation, the Caribbean Bank, and the UNICA staff.

APPENDIX. A-2 AS AN ENERGY ALTERNATIVE FOR THE CARIBBEAN WORKSHOP
Barbados, December 6-8, 1981

WORKSHOP SESSION, GROUP NO. 1
EDUCATION AND TRAINING NEEDS

Report by: Howard Horenstein, Moderator

This workshop session was attended by 15 persons representing nine countries:

1. Quilvie Cabrat, Dominican Republic
2. Ronin S. Cristobal, Dominican Republic
3. Homero Poot, Dominican Republic
4. Michel DuPont, Guadeloupe
5. Jessel Edwards, Antigua
6. Hopeton Gordon, Guyana
7. Howard Horenstein, Florida, USA
8. Rivet Hughes, Anguilla
9. Robert J. Martin, Puerto Rico
10. Paul Neva, Barbados
11. Renate Biter, Dominican Republic
12. José B. Rodriguez, Dominican Republic
13. S. Sathyanarayanan, Trinidad
14. Melanio Soria, Dominican Republic
15. Robert Sullivan, Florida, USA

To stimulate discussion, the workshop...

The text specifically addressed three general questions related to wind energy education and training activities in the Caribbean, noting regional differences where possible. The three questions were:

(1) What has been done in wind energy education and training in the Caribbean?
(2) What should be done in wind energy education and training in the Caribbean in the future?
(3) What is the mechanism by which it may be accomplished?

To gain an understanding of the general state of affairs in energy education and training in the region, as well as the present and future needs, a poll was conducted among the participants to determine their assessment of these conditions. The results are noted in Table 1. It may be observed that the participants rated an average score of 2.9 which is equivalent to "little activity" for the present state, and a score of 1.8 which is between "moderate" and "active" for the desired future state.

From this poll and the ensuing discussion, it was concluded that the entire region needed to strengthen its educational and training programs along the subject lines listed in the categorical headings of Table 1. These categories are as follows:

(1) Engineering education programs at the baccalaureate level
(2) Science education programs at the high school and university levels
(3) Continuing education programs at the professional level
(4) Community education and training programs at the consumer and technician level
(5) Scientific community education at the high school and university teacher level
(6) Modification of high school and university curriculum to place increasing emphasis on alternative energy related subjects

(7) Videotape information dissemination through television network programming
(8) Cooperative educational programs which place educational emphasis on industrial experiences

Recommendations:
The workshop prepared specific regional recommendations as a result of the discussions which took place. These

The recommendations are as follows:

(1) A resource assessment should be conducted to determine the existing capability in alternate energy education and training in the region.

(2) Scientific and technical requirements should be determined to facilitate a viable wind energy utilization program in the Caribbean. Specifically, a study should be performed to determine the educational and training requirements for the region in wind energy.

(3) A program should be developed to add to the capability needed in recommendation #1 to meet the requirements outlined in recommendation #2.

(4) Encourage active involvement of regional institutions in carrying out recommendations #1-3.

(5) UNICA should sponsor regular meetings whereby university faculty, researchers, and education and training specialists can assess the status of completing recommendation #4.

(6) Liberal use of the following mechanisms should be used to accomplish the necessary educational and training mission:
Short courses, Institutes, Fellowship program, Correspondence courses, Curriculum development packages, Post-doctoral programs, Sabbaticals, Symposia and conferences, Faculty and researcher exchanges, Videotapes of demonstrations and applications.

(7) A focal point for coordinating laboratory, training and instrumentation needs in the Caribbean should be created. This should include university coordination, inventory of personnel and equipment, and cataloging of available industrial and governmental assistance. UNICA should be this focal point, with the actual performance to be done under the granting mechanism.

In addition to the general recommendations above, a few participants submitted detailed comments and recommendations pertaining to their specific countries. They are as follows:

Dominican Republic - NGftez, Roman, Rodriguez, DePool, Sbriz

(1) What is being done in the Dominican Republic about making the general public aware of energy problems?

(2) The National Commission on Energy Policy has a sizeable program of seminars.

Success?

Higher education institutions, universities, and institutes offer courses and seminars to their members where current energy-related problems are presented. What additional steps should we take?

(a) Promote the idea within the higher education system to offer graduate courses and/or master's degrees related to the management of energy resources.

(b) Suggest to these same systems to introduce a mandatory course on energy-related problems in all of their professional programs in technical areas, and at the same time consider energy problems in the context of their programs which, in one way or another, address these same issues.

(c) Encourage university students to focus their theses on specific energy-related problems of the country.

(e) Make those with decision-making power in the government conscious of energy problems, so that they take them into consideration when formulating government plans.

(f) Create educational campaigns in secondary schools, guiding students at this level on this matter.

(g) Offer ample facilities to rural areas to install windmills for their use in obtaining the necessary water for their communities.

How can we make this campaign a success?

Reality, what can we count on and what do we need for this? To bring this campaign into reality, we count on institutions involved with the transformation of energy, and others dealing with the management of energy resources who feel the closeness of the world crisis of these resources. However, their influence on government officials is not enough and their available means to bring to fulfillment educational programs is very limited. In short, we can presume that to bring a complete educational program that correctly informs on the reality of these problems, we need financial resources and the necessary personnel, capable and conscious of the significance of these

problems to the future of our country.

The next part of the text appears to be corrupted or encoded and is not readable.

ADDX, D-3 WIND AS AN ENERGY ALTERNATIVE FOR THE CARIBBEAN WORKSHOP

Barbados, December 6-8, 1981 WORKSHOP SESSION, GROUP NO. RESEARCH AND DEVELOPMENT FIELDS Report by Dr. Edwin Nunez, Moderator

This workshop session was attended by eleven persons representing ten countries from:
1. Nitier Puerto Rico
2. Melvin Sanktos Guyana
3. Sixte Wout Curacao
4. Stephen Lamming Barbados
5. Lester Nelson Grenada
6. Joseph Lanick Montserrat
7. Michael Canoy U.S. Virgin Islands
8. Richard L. Simon California, USA
9. José B. Rodriguez Dominican Republic
10. Maharaj S. Tomar Venezuela
11. David S. Renne Washington, USA

RESEARCH AND DEVELOPMENT--SEPARATE VS. UNIFIED APPROACH

A glimpse of a map of the Caribbean region will show a great assortment of island-countries with diverse cultures and languages. Upon closer scrutiny, this first impression will be transformed and attenuated by the realization that there are many common goals and aspirations. Each country is striving to give a maximum number of its citizens a high

Standard of living without creating major environmental damage or exacerbating social tensions. By the same token, they share similar problems and obstacles which hinder their development. In general, the islands are very small-sized with large population densities, have scant natural resources, and the sea acts as an imposing barrier which impedes communications and access to the outside world. Therefore, before the Caribbean countries elaborate on specific energy research and development policies, they must decide whether their interests will be pursued separately or through a unified approach. The latter alternative implies the pooling of resources by different countries. Criteria such as proximity, common language, complementarity of their resources or previous cooperation experiences might induce countries to unite in one or more groups. Table I presents some of the advantages and disadvantages resulting from Caribbean countries working separately or unified in the elaboration and implementation of truly energy research and development policies. It is the belief of the participants of the research and development needs workshops that the advantages of a unified approach far outweigh the disadvantages. Consequently, Caribbean universities, governments, and institutions dealing with R&D should make an effort to establish one or more regional groups in which individual countries can contribute their resources to complement each other's weaknesses.

Research and Development - Constraints

Caribbean countries, utilizing different philosophies to address their idiosyncrasies, are striving to achieve development in the shortest possible interval of time. In a world that gets more complex every day, this endeavor becomes increasingly difficult. R&D is much harder to undertake in these countries than in industrialized nations.

Workshop participants agreed on the following list as the most important impediments to their R&D efforts.

1) Isolation - Quite often, the scientist or engineer.

The revised text:

He finds that he is the only person in the country or institution with advanced specialized knowledge in a particular field (e.g., wind turbine design). There are very few opportunities to share his knowledge with other specialists in his field. Libraries lack the most current journals or books.

(2) Lack of Infrastructure - The infrastructures needed to deploy, operate, and maintain new technology are virtually nonexistent.

(3) Overinvolvement - Being one of the very few technically trained people in a country means that a large number of people will request his involvement in a wide variety of projects. His attention will likely be spread too thin for each project, resulting in meager progress and results. Many times he has to work in areas outside his field of expertise.

(4) Finances - Governments allocate scant resources for R&D since they respond to pressures exerted by groups with more political leverage than scientists and engineers. Financial restrictions force scientists to leave many areas of a particular problem untouched.

(5) Government and - Governments show little understanding of the importance of R&D activities in a developing country. New techniques are usually met with skepticism and resistance by the civilian population.

(6) Lack of Peer Participation - Many of the organizations that disburse R&D funds in the Caribbean do not have proper participation from scientists and engineers. Funds are allocated by people who lack a real understanding of R&D.

RESEARCH AND DEVELOPMENT - Wind energy has the potential of becoming an important alternative energy source for the Caribbean basin. It was agreed that the following areas need immediate attention in order to realize that potential in the near future.

(2) Before wind turbines can be deployed on a wide scale in the Caribbean, each island must have detailed knowledge of its wind resources.

(3) Siting studies have to be conducted in order to search for the best locations to install both large and small scale wind turbines.

Wind turbines, (3) Evaluation of existing adaptive technology and the development of solutions which might suit local needs. (4) Operations and maintenance research in order to test materials resistance to salt corrosion, hurricane winds. (5) Testing of local wind turbine designs and adaptations. (6) Research on the economic and social impact of new technologies. (7) Evaluation of existing energy production and utilization systems to achieve energy savings through conservation and second-law efficiency considerations. This offers the potential for saving the greatest amount of energy in the shortest interval of time.

IV. RECOMMENDATIONS: In order to satisfy the aforementioned R&D needs, the workshop participants make the following recommendations to UNICA, CDB, CARICOM, and any other agencies dealing with the development of the region:

1) Top priority should be given to wind resource assessment proposals and wind siting studies. Within a period of four years, all Caribbean islands should know their capacity.

2) Projects and studies should be funded which consider the economic, social, and legal impact of alternative energy systems, in particular wind turbines.

3) It is deemed important to sponsor projects which use an integrated system of energy approach such as solar/biomass, wind/hydro, wind/solar, etc. The domestic, industrial, and agricultural applications suited to the particular country's milieu should be explored.

4) Research into the problems associated with the operations and maintenance of alternative energy systems should be undertaken. Special attention should be given to the problems associated with materials and parts resistance to salt corrosion and protection from hurricane force winds.

5) Local wind turbine designs and adaptations should be encouraged. Development projects whose purpose is to establish the manufacture of wind turbines and other alternative energy systems within the region should also be encouraged.

6) The active participation of scientists and engineers in the development and implementation of these projects and studies is crucial.

Boards and committees of institutions that disburse funds in the Caribbean are considered essential. The peer review method is recommended for the evaluation of all proposals and publications. Priority should be granted to projects that explore energy production and utilization systems. Energy conservation and secondary potential of efficiency projects offer the potential of saving vast amounts of energy in the region. It is suggested that a survey should be conducted of the available human resources in the region with expertise in energy R&D areas. After the survey is conducted, a human resources and project directory should be published and an institution, or institutions, should be designated as a clearing-house for locating expert resources in each area such as wind, biomass, solar, etc. Any similar efforts that have already been undertaken in the region should be more readily available. Greater awareness of what others are doing or have done is needed. Conduct regional seminars on fund availability and on the proper techniques for the preparation of proposals to be submitted to the regional development agencies. An institution or institutions could be designated as a clearing-house of this information.

It is strongly recommended that, whenever possible, alternative energy development meetings for the region take the workshop format, similar to the present UNICA meeting. The conference should discuss openly what are considered to be the successes and failures. Reports should be written and published so that conference results are widely available. Abstracts of papers to be given at a conference should be available with sufficient time before the meeting. Prospective participants can decide wisely on whether to attend or not based on this information.

It is felt that the use of wind as an energy alternative for the Caribbean can be accelerated if programs are designed by the development agencies which convince governments of the necessity of granting tax incentives to people who install a wind turbine.

This allows individual consumers to sell energy produced by a wind turbine to the power company, similar to PURPA in the United States. Projects designed to create the appropriate infrastructure necessary for R&D and for the deployment, operation, and maintenance of wind turbines should be funded.

Table 1
Advantages and Disadvantages Resulting from Caribbean Countries Elaborating and Implementing Their Energy Research and Development Policies Separately or Unified

Advantages
Separate (each country having an individual approach)
- Country can pinpoint its own R&D needs very precisely and work on it
- Country can proceed at its own pace without being bound by others

Unified (groups of countries working together)
- Cost savings. Pooling of resources will mean lower planning, equipment, and data analysis costs
- Countries can complement each other's needs by sharing their human and technical resources
- Region-wide spirit of cooperation
- Possibility of pooling together to purchase alternative energy systems (wind turbines, digestors, etc.) at a reduced price

Disadvantages
- Higher cost to each individual country
- Lack of technical and human resources will probably require more intensive foreign (outside of Caribbean) participants
- Potential political problems
- Delays in getting tasks done due to the necessity of allocating limited resources to various countries

Appendix D-4
Wind as an Energy Alternative for the Caribbean Workshop, Barbados, December 6-8, 1981
Workshop Session, Group No. 3, Demonstration Needs
Report by Dr. Modesto Inurte, Moderator

The workshop was attended by eight people representing six Caribbean countries:

1. Cristobal Roman, Dominican Republic
2. Inewne Sorte, Dominican Republic
3. Sin Sparks, St. Lucia
4. Greer Guarda, Mexico
5. Peter Willems, Barbados
6. S. Anwutsont, USA
7. Dellimore, Barbados
8. Modesto Inurte, Puerto Rico

It was found that each country has different demonstration projects in wind power uses, but they were unaware of each other's activities. It is suspected that this same problem exists in other regions.

The lack of communication and flow of information between various Caribbean nations not represented at this workshop exists. This was further highlighted by the participants who stated that each country has its own specific needs, and therefore identification of future demonstration needs will be appropriate once these needs are taken into consideration. Local needs in many areas take such things as oil displacement needs, isolated community needs, and the need for electric power to solve critical issues into account. These might include providing energy to operate certain sanitary and health facilities as well as other social needs, and legal problems involving generation restrictions for personal use and/or sale. For example, in St. Lucia, one cannot generate their own electricity without violating social laws. This presents an obstacle to wind turbine generator (WTG) development.

The group generally agreed that wind power assessment processes in various areas should be encouraged and that small demonstration projects should be developed as soon as possible and/or in parallel with assessment. To address the subject of demonstration needs, the group recommends that an inventory of existing demonstration projects in the area be first made. The purposes of this inventory completion are:

1) to prevent duplication of efforts,
2) to provide assistance with the database,
3) to give funding agencies information on projects needing funding and projects which have been funded by others,
4) to provide a working basis for future projects,
5) to give directions for future developmental thrusts.

To carry out the above recommendations, a questionnaire should be prepared. A suggested questionnaire could include:

Typical information needed:

- Country and agency involved, contact person
- Location of unit: are maps available? Are photographs available?
- Purpose of unit: water pumping, electricity production, mechanical, other

Designer (if unit locally built): (a) level of local component in design and manufacture of unit. If locally built, are plans or support available? Funding Agency: (a) privately owned (b) government funded (c) funded by outside source (d) other. Is wind data available? (1) at site location (2) at other locations. Condition of unit: (a) under construction (b) working (c) needs repair (d) planning stages.

If working, performance of unit: (a) details.

If needing repair: (a) advantages to repair (b) estimation of cost (c) details. If in planning, has funding been acquired? Identify type of future demonstration projects needed in the: (a) estimation of cost (b) planning requirements (c) possible funding agencies (d) specific help you would like to secure.

A set of short-term objectives (say for 6 months' accomplishment) was outlined by the group participants as follows:
(1) Catalog existing wind turbine installations.
(2) Pursue the reactivation of abandoned wind turbine projects.
(3) Removal of obstacles to wind turbine development; legal problems in different areas.
(4) Rate structure consideration from wind sources.
(5) Identify incentives to promote wind turbine development.
(6) Emphasis should be placed on turbine systems that can be manufactured locally.

Ener. Cristóbal Román from CDE, Dominican Republic, suggested and the group unanimously agreed that a simple procedure to make the inventory should be followed consisting of: (1) preparing the questionnaire (2) mailing it to the various contact people and those attending this symposium (3) receiving and summarizing data (he offers himself, but feels UNICA should do it).

To those who are in arrears in returning the information questionnaires, organization of one project coordinator under UNICA staff, using available UNICA staff services such as office, secretary, communication, and reproduction, is proposed. This coordinator would be the contact person in each of the areas from whom he will obtain the information. 'The information follow up or updating...

Data will be gathered, reduced, and published. An evaluation should be attempted every year. This information would provide a database for various countries to reduce duplication efforts and be in a better position to present proposals for requesting funds for their projects. Other aspects in which this activity could be beneficial include accelerating the development and use of wind power, pricing and costing of power produced, determining appropriate sale back prices of electricity to local utilities, etc.

This information would identify the difficulties and failures of existing demonstration projects and provide guidance in implementing procedures for documenting and reporting the operation of these projects.

Funding:

The group's opinion is that funding should be addressed jointly from the identified needs of the three workshop groups. However, for this job, at least 5 man-years should be assigned to the project coordinator plus travel expenses. When budgeting, it can be estimated that 5 man-years of secretarial services will be needed, in addition to overhead costs of office, telephone, reproduction, etc. Additional personnel are required for the contact persons. It is suggested that this cost be borne by the local interest groups or local government.

Appendix D-5. Wind as an Energy Alternative for the Caribbean Workshop.
Barbados, December 6-9, 1981.

Evaluation:

At the close of the workshop, an evaluation questionnaire was given to each participant to solicit their reactions to this type of activity and to obtain individual recommendations for improvement or modification of similar future conferences. The tabulated results of this evaluation exercise are attached hereto. As the tabulation shows, the majority of respondents (78%) gave "Good" (one step below the maximum "Excellent") to the Workshop. It's also worth noting that the group discussion format received the highest percentage (55.26%) of "Excellent", while the question on speakers received the lowest "Excellent" rating.

Percentage (3.86%). Another interesting finding is that 17.28% of respondents indicated that they were unaware of the UNICA Project goals. An overall rating of these other observations, criticisms, and suggestions will be taken into consideration in the organization of future workshops, in particular the biomass workshop scheduled for the spring of 1982 in San Juan, Puerto Rico under the UNICA Project.

WIND AS AN ENERGY ALTERNATIVE FOR THE CARIBBEAN WORKSHOP EVALUATION

Question Number Percent

1. Organization and Logistics
Excellent - 27.8%
Good - 58.6%
Fair - 13.8%

2. Workshop Discussion
Excellent - 55.2%
Good - 44.8%

3. Overall
Excellent - 22.44%
Good - 77.56%

4. How successful was the workshop in meeting the goals of the UNICA Project?
Very successful - 20.7%
Successful - 39.7%

Somewhat successful - 31.5%
Not successful - 3.48%
Unaware of the UNICA Project's goals - 12.5%
Other answers - 3.8%

TOTAL RESPONDENTS: 29

APPENDIX E

Report on Wind as an Energy Alternative for the Caribbean Workshop
San Juan, Puerto Rico
April 28-29, 1982
UNICA Commission on Science and Technology

APPENDIX E-1

BIOMASS AS AN ENERGY ALTERNATIVE FOR THE CARIBBEAN WORKSHOP SUMMARY REPORT

It is the opinion of the UNICA Science and Technology Commission that the April 28-29, 1982 San Juan Workshop on Biomass as an Energy Alternative for the Caribbean was a greater success than the first workshop on Wind because of many circumstances. Some of the most favorable conditions were the familiarity of the UNICA contact.

The following text has been corrected for clarity and coherence:

People involved in the project found it stimulating, which sparked a diverse interest in their involvement and commitment to its success. The workshop followed the "Fuels and Feedstocks for Tropical Biomass" seminar, which provided a unique opportunity for UNICA contact persons to familiarize themselves with the subject.

Like the format of the Wind Workshop, the group was separated into three working sessions: Education and Training Needs, Research and Development Needs, and Demonstration Needs. From the recommendations made, it is clear that biomass is perceived as one of the energy alternatives for the Caribbean that could be utilized faster based on the agricultural experience and know-how of the region.

A generalization of the recommendations can be formulated as follows:

1) Securing funding to establish research, development, and demonstration projects of a specific nature in the region on biomass as an energy source should be a top priority.

2) In order to implement the above recommendation, education and training programs to prepare the human resources required for tropical biomass in the region are essential.

3) UNICA should play a vital role in technology information dissemination, R&D project evaluation, and technology transfer between their member institutions.

4) The role of the UNICA Foundation in securing funds for the implementation of the above is essential and indispensable to carry out such programs.

If the above recommendations are implemented, the science and engineering capabilities of UNICA member institutions in biomass matters would greatly improve. Furthermore, the role of universities and research institutes as providers of solutions to society's problems would be significantly strengthened.

The UNICA Science and Technology Commission wishes to thank all the UNICA contact persons for their participation in the workshop, particularly the moderators of the sessions who drafted the workshop reports. We are also deeply grateful for the funding support from the National.

Defence Foundation, Exxon Education Foundation, and the UNICA Foundation.

APPENDIX, E-2 BIOMASS AS AN ENERGY ALTERNATIVE FOR THE CARIBBEAN WORKSHOP

San Juan, P.R., April 28-29, 1982

WORKSHOP SESSION, GROUP NO. 1 EDUCATION AND TRAINING NEEDS

Report by Dr. R.L. Sullivan, Moderator

Experts in the Education and Training Workshop session include:
Dr. Jaime Suscarre (University of Puerto Rico)
Eng. Gerardo Manan Paniagua (INTEC, Dominican Republic)
Lourdes Iturrolde (Universidad Simón Bolívar, Venezuela)
Mr. William Chalmers (Caribbean Development Bank, Barbados)
Dr. Linda S. O'Brien (University of the West Indies, Jamaica)
Mr. Gerald Leler (University of the West Indies, Jamaica)
Dr. R.L. Sullivan (University of Florida, USA)

Recommendations (G2) UNICA should decentralize the work of the Commissions into technology working groups and increase the number of contact people. (2) To fund the increased activity stemming from the new structure UNICA should actively seek new additional funding for a three-year budget. (3) Each working group should be encouraged to submit budgeted

Proposals to the appropriate Commission to fund specific activities e.g., workshops, continuing education programs, etc. (4) Each working group should establish communications and data collection procedures. (5) UNICA should fund exchange programs among Caribbean universities as a means for improving the transfer of new technology knowledge in the region. (6) UNICA should sponsor a special Workshop on education with an emphasis on university curriculum development and communication techniques aimed at improving the region's awareness of the various new technology options. (7) Each was the state of, group should publish an edited volume describing

the content of its specific technology for each country in the region. (8) Each working group should be responsible for promoting its specific area of concern within the Commission. (9) Video cassettes should be made for each technology to promote its development and use among.

Teachers and public officials.

Appendix E-3: Biomass as an Energy Alternative for the Caribbean Workshop

Sun Duen, P-R., April 28-29, 1982

Workshop Session, Group No. 2: Research and Development Needs

Report by Dr. Al Binger, Moderator General

It is the general view of the working group that there is great need for collaboration and exchange of technological know-how between member institutions. It is felt that UNICA must address itself to the development of a mechanism to allow for such transfer. It is also commonly felt that there exists in the region various technologies which are needed in other countries. The efficiency of UNICA members is being affected by:

1. Inadequacies in the procurement and dissemination of information
2. Obstacles preventing collaboration between regional institutions.

UNICA could be an efficient organization in the development and propagation of science and technology in the region if it could overcome some of these problems.

Research and Development: These are short term recommendations aimed at stimulating developmental work for various UNICA members and at addressing certain problems which some members are presently having.

We interrelate our project goals in energy with those for the protection of the environment and construct our project proposal in order to take advantage of all funding which exists in other areas such as environment protection, agriculture, etc. Attempts should be made to have joint projects developed whenever possible, realizing that projects must be specific nature for the sites involved. One of the main potentials seems to be for the utilization of cocoa and coffee waste in generating biomass. We should recognize that duplication can be both good and bad. However, duplication should result in more efficient use of funds. Wherever possible, UNICA should speed up the distribution of funds coming into the region for R&D and whenever time allows before importing foreign technology, we ask UNICA personnel if such technologies had been.

Previously tested in the region and with what result. Projects aimed at utilizing biomass as chemical feedstocks should be given priority. The orientation of such projects is more technologically and financially demanding, but they are potentially more feasible. It is therefore recommended that all such projects be undertaken in collaboration. The UNICA representative in each country, after consulting with his colleagues, should identify the areas of research and development with specific input and submit these to UNICA for processing. Hopefully, this will provide a current assessment

of energy R&D in the region. A techno-economic evaluation unit should be established to provide this service for cost-benefit analysis to deduce the benefit of the project. In developmental work, all pertinent data from the region should be supplied so as to allow analysis for site and regional applicability and potential. U.S. AID policies in the region should be evaluated to see how they promote: (a) regional collaboration (b) developing expertise within the region.

As there is a present funding shortage, it is suggested that UNICA solicit funds in an effort to act as a source of interim financing for collaboration projects with regional application. Closer working contacts should be maintained with research and development institutions in the region as these institutions usually have more funds, personnel, and equipment to assist the developmental phase of projects. UNICA would therefore seek funding for the actual development of collaboration of regional projects. We accept the offer of collaboration from French Overseas University Programs offered by Professor J. Kencux of AUPELF. UNICA should make representation to funding agencies for funds to aid in organizing this information service and to provide the required training to allow the transfer of technology from this source to the countries where it can be utilized. Until an information machinery is in place for the dissemination of information.

Person-to-person communication should be undertaken. Since the existing questionnaire is viewed as being difficult to comply with, it is suggested that each person supply their current project with their immediate needs for information and funding so the UNICA Secretariat can provide whatever short-term assistance it can. UNICA should include in its current publications a section on research projects stating: institution, persons, projects in progress and current status, projects in planning, projects in which institutions are seeking collaboration, funding availability and requests for assistance from members. This will allow UNICA contact persons to be aware of funding availability for research and distribute this information to people whom they think can benefit from it.

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"UNICA should provide short-term assistance. It should include in its current publications a section on research projects, stating: institution, persons, projects in progress and their current status, projects in planning, and projects in which institutions are seeking collaboration. It should also mention funding availability and requests for assistance from members. This will allow UNICA contact persons to be aware of funding availability for research and distribute this information to

people who they think can benefit from this.

UNICA should consider providing the following:

1. Information updates.
2. Assistance in locating institutions with similar programs.
3. Help in obtaining funds for holding symposiums to allow for person-to-person technology transfer and to solve problems.
4. Efforts to strengthen technology in the area.
5. Encouragement for contact persons to become intimately involved in keeping their colleagues informed on technological development and funding availability in their respective fields of research.
6. Improvement of the level of communication and information dissemination with these contact persons, in order to further fulfill their functions.

Some financial incentive for the additional work that the contact person will be required to do in the various countries ought to be examined. A major function of UNICA should be the provision of funds. Unfortunately, its present structure does not allow for it to function as a funding agency.

In recognizing the integral association between research and funds, we strongly recommend that UNICA consider approaching funding agencies such as FAO, CIDA, UNDP, UNESCO, CES, OAS, CLADE, CDE, Ford Foundation, Kellog Foundation, etc., with the aim of discussing how UNICA can obtain funding for regional projects.

For short term funding in areas such as biogas, which has wide regional applicability, it is suggested that funds for environmental work be structured whenever possible to be equivalent to environmental protection projects and thus become eligible for funding."

Break --- In our group, we paid attention to three basic questions which we felt were fundamental to the success of UNICA. These were: 1) the ongoing R&D project in energy within the region, 2) the requirements of our individual institutions from UNICA, and 3) proposed methods which UNICA will employ to meet these. Addressing the first question was extremely limited as we realized that such information, instituted by UNICA, had not yet had the anticipated result. We supposed that some time before the conclusion of this session, all persons actively involved give a brief report on what they are expecting and state whether they are interested in any form of collaboration.

The second requirement was for education in institutions where technology is developed for the masses (e.g., charcoal project) in association with UNICA's know-how, heroes, and potential users as to the operations techniques for that technology. The special factors involved in giving new technology to our people cannot be overlooked. In order to meet these needs, we proposed that UNICA consider the establishment of a program for educating bureaucrats, and then an associated demonstration program for the populace in the need and utilization of such technology.

Information System is critical to the success of UNICA. This Information System is to be developed in collaboration with OLADE, TEU of GB, CALIR! SRC and other regional institutions. The prime purpose of this unit will be to acquire and disseminate information to UNICA contact persons in

each country.

APPENDIX E: BIOMASS AS AN ENERGY ALTERNATIVE FOR THE CARIBBEAN WORKSHOP

San Juan, PR, April 28-30, 1989

WORKSHOP SESSION, GROUP NO. 3 DEMONSTRATION NEEDS

Report by Mr. Modesto Iriarte and Mr. Salvador Lugo

Moderators: This workshop was attended by a small group (six persons) representing Guyana, St. Lucia, Jamaica, Netherlands Antilles, and Puerto Rico. At the onset, the group decided to establish the following criteria for the selection of demonstration projects:

(1) availability of Biomass on a commercial scale;
(2) the biomass would be in an existing commercial activity;
(3) the projects would be of such a nature that they could be done elsewhere in the Caribbean (technology transfer);
(4) projects should be culturally acceptable to the region and the countries involved.

With this criteria in mind, a discussion was held of the various Biomass related activities being carried out in each of the regional areas mentioned. Various projects with potential for developing into "demonstration" stage were discussed. Several were identified as needing further R&D, others were ruled out because enough commercialization has already been developed or because they were not of general interest to the majority.

While sifting through the options, the countries kept in mind in terms of biomass potential were Guyana, Jamaica, St. Vincent, Haiti,

Dominican Republic, Venezuela, and Colombia. There could be others. Only one demonstration project was identified and discussed at length for implementation. Discussions and reasons for discarding other projects are presented. The general consensus is that a demonstration project to enhance the use of Biomass would be very convenient for the Caribbean.

"It's probably the best type of fuel for direct combustion; its preservation and bonding use offers advantages even over fuel oils. The suggested project could start with a conference workshop sponsored by the University of Guyana and producing positive gas, on the management of the forest industry. The gasifier has been developed by a German firm. The conference in Guyana would include a series of lectures on the operations, experience, and design details of the Guyana facility ecosystem, impacts of the region as well as a visit to the plant. After the conference, a task force would be identified to work in the development of this project. The task force could proceed in the following ways: (1) make an initial assessment of the process, the logistics management, and outline a plan based on selected sites; (2) prepare a proposal for securing funding from private and government agencies; (3) implement the proposal when funding is secured.

Other Projects Discussed:

(1) Direct burning of biomass was discussed. It was concluded that for small capacity boilers there is a long history of commercial projects in operation. Demonstration needs are required for large utility boilers but the interest would be centered on a small number of the most developed countries such as Puerto Rico, using large blocks of electrical energy.

(2) Water hyacinths used for tertiary treatment as a source of bio-gas. This project was discussed and it was concluded that it is feasible but that there is not now too strong an incentive in developing a demonstration project.

(3) Sea weeds as a source of biomass. This was discarded because it requires full research before a demonstration unit can be attempted.

(4) The need for a bank in biomass for the Caribbean was discussed and it was concluded that UNICA has a separate project on this.

(5) The need to determine: (a) Life-fuel consumption in the Caribbean; (b) Charcoal uses; (c) Firewood uses. This can help in identifying further demonstration projects.

Other Recommendations for consideration at some future time."

Effort for demonstration projects: We wish to put forth the following possibilities: Biogas or proteins from the banana operation at St. Lucia; explore in Antigua the possibility of biogas from the expansion of pork and poultry production. In Dominica, explore the possible use of wastes from coconut users and from food processing.

Appendix B-5, Biomass as an Energy Alternative for the Caribbean Workshop, San Juan, P.R., April 28-29, 1982

Evaluation: At the close of the conference, an evaluation questionnaire was given each participant to elicit their reactions to this type of event and to obtain individual recommendations for improvement or modification of similar future conferences. A tabulation of the results of this evaluation follows:

Tabulation of Evaluation Questionnaire of UNICA Workshop on Biomass as an Energy Alternative for the Caribbean

Totals: Excellent, Good, Fair, Poor, Responses

Organization and logistics: 4, 6, 3, 2, 13, 100

Speakers: 2, 8, 6, 3, 13, 100

Workshop discussion: 2, 9, 9, 2, 13, 100

Overall: 2, 8, 0, 13, 100

How successful was the workshop in meeting the UNICA project goals? Very Successful, Somewhat Successful, Not Successful, Unaware of Project: 0, 6, 6, 1

Languages used among participants were diverse.