

"Center — Where The Energy Alternatives for the Caribbean" by Dr. Juan A. Bonnet, Jr, Director. Presented at Seminar on "Wind as an Energy Alternative for the Caribbean", Georgetown, Barbados. Center for Energy and Environment Research.

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Energy Alternatives for the Caribbean By Dr. Juan A. Bonnet, Jr, Director, Center for Energy and Environment Research, University of Puerto Rico. Presented at Seminar on "Wind as an Energy Alternative for the Caribbean", Bridgetown, Barbados, December 7, 1981.

Introduction: For the developing countries, there was some good news from Geneva at the end of November. The Organization of Petroleum Exporting Countries (OPEC) agreed to increase world oil prices to US\$34 a barrel, but it also decided to freeze this basic price until December 1982, thus protecting poorer countries from unexpected and unmanageable increases. Yet, unless long range steps are taken soon, the OPEC action may not be enough. Nearly 100 developing countries depend on oil to meet more than sixty percent of their energy needs. Most of them import four-fifths of their total oil requirements. The price of oil, in inflation-adjusted terms, has quintupled over the past decade (See figure 1), and many analysts predict price increases of three percent annually. This means the poor countries are now spending \$50 billion a year to pay for imported oil and may be paying \$110 billion a year by 1990. To offset this economic drain, many countries are turning to what could be the most readily available alternative supply. Forty percent of the developing world's timber reserves may literally go up in

Barrel US. Dollars. Figure 1 - Oil Prices, Annual Means 1972-81.

smoke, as households and small industry substitute firewood for oil. In a number of Caribbean countries, exploitation of wood resources is not an option due to limited availability.

Equilibrium is maintained with regeneration rates. Wood and charcoal fulfill a large part of Haiti's energy requirements. This is also true to a lesser extent for countries with forest reserves such as Belize, Guyana, and St. Lucia. While developing countries contain two-thirds of the world's population, they only account for one-seventh of the world's energy production. The degree to which developing countries can reduce their dependence on imported energy will greatly determine their future economic flexibility.

Since the Arab oil embargo of 1974, the debt of developing countries has more than quadrupled to £425 billion, resulting in a larger portion of their income being allocated to debt service at continuously increasing interest rates. The World Bank estimates that up to 30 percent of the developing world's energy needs could be eliminated by 1990 through maximising conservation efforts and increasing energy production from various fuel sources such as oil, gas, coal, hydropower, and renewables. Moreover, it has proposed ways to reduce energy needs by 15 percent without sacrificing economic growth in the coming decade.

In recent times, there has been increased discussion about energy. Last November, countries from both the southern and northern hemispheres discussed energy at the Cancun, Mexico Summit Meeting. Prior to this, in August, there were numerous discussions about renewable energy at the United Nations Conference on New and Renewable Sources of Energy in Nairobi. For months, there have been ongoing discussions about a World Bank proposal to establish a separate energy affiliate within the bank. However, no concrete agreements have been reached to date.

On a different note, the Inter-American Development Bank (IADB) reports that crude oil production is growing faster in Latin America than in any other region of the world. According to a 1980 report on economic and social progress in Latin America, oil production in the region expanded by nearly 10 percent, thereby increasing the region's share.

The oil production of the world markedly rose from a certain percent in 1977 to 9.8 percent in 1980. By the year's end, the total oil output of the region had reached 2.123 billion barrels, exceeding consumption by about 700 million barrels, an increase of 100 million barrels over 1979. The rate of growth in production was the highest since 1973 and compares favorably with the 8.5 percent expansion of 1979. The combined production of Mexico and Venezuela accounted for nearly 75 percent of the region's crude oil production from 1975 to 1980, although Venezuela's share fell from 53 percent in 1973 to 37 percent in 1980. Meanwhile, Mexico's production rose from a certain percent of the region's output to 37 percent during the same period. Regarding oil exportation, "the single most important event during the past five years has been Mexico's contribution to the region's increased sales of crude to external markets," the IADB report said. Mexican reports indicate increases of 116 percent in 1977, 79 percent in 1978, 47 percent in 1979, and 55 percent in 1980 when they totaled about 303 million barrels. Production also expanded in Argentina, Brazil, Chile, Peru, and Guatemala, but it declined in Bolivia, Trinidad, and Tobago. In Venezuela, production declined by almost 8 percent as a result of conservation measures enforced by the government.

The Mexican and Venezuelan governments are implementing an important oil purchasing financing agreement for the Caribbean. The New York Times editorialized recently that the Caribbean is being rediscovered. The agreement covers up to 80,000 barrels per country. According to the agreement, a sum equivalent to 30 percent of the value of the crude purchased by the recipient country will be financed by the Venezuelan Investment Fund and the Central Bank of Mexico. The loan will be given for five years at a 4 percent rate of interest. If, however, money is invested in development projects, preferably in energy, the loan will be extended for twenty years and the rate of interest will be lowered to 2 percent.

The World Bank has also called for an international research program to improve and broaden the use of renewable energy technologies in developing countries. The Bank, in a recent report, "Mobilizing Renewable Energy Technology in Developing Countries: Strengthening Local Capabilities and Research," particularly emphasizes the role of biomass in the developing countries. Although in some countries up to 90 percent of the energy consumption comes 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 executed biomass research program would improve the productivity of conventional biomass materials such as sugarcane, cassava, and sweet sorghum, and identify species that are potentially more productive. The research should be conducted in forestry 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, small hydro 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 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 with 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 Basic Support
 - a. Energy planning
 - b. Information and dissemination
 - c. Training

2. Integral Regional

The text should read:

Development in a. hydroelectric, b. firewood and charcoal, c. liquid fuel production, d. solar energy, e. vegetable residues, f. geothermal energy, g. biogas, h. wind power in the Caribbean Region. The share of crude petroleum and refined products in total merchandise imports in the Caribbean region increased from less than 9 percent in 1971 to about 25 percent in 1980. Petroleum imports to the region increased during 1972-77 from \$150 million to \$620 million in 1980, since all Caribbean countries with the exception of Trinidad and 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) indigenous fuels have not been able to replace the use of imported petroleum; 3) there are no established markets for indigenous fuels; 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.

The commercial sector's demands for electric energy in the smaller islands are frequently dominated by the services (tourist and commerce) industries, in some cases accounting for up to 50 percent of all the electrical energy consumed in the country. Residential electric energy consumption accounts for approximately 20 percent. To solve the energy problems in the Caribbean Region, we must first recognize that there are large amounts of natural energy in the area which are not utilized. This situation arises from our own common geographical and ecological circumstances. The potential for renewable energy is only beginning to be explored by the region, and some countries are exploring the possibilities.

Now being recognized for nonconventional sources through research and demonstration. A consultant for the United Nations Development Programme (UNDP) concluded recently 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 CDCC member countries'. 'The Action Plan for the Caribbean Environment Programme' calls for:

- 1) Assessment of major sources of non-conventional energy and their potentials for utilization.
- 2) 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 sub-regional 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 this paper 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), with the Caribbean Development Bank (CDB) and CARICOM, as implementing agencies, has been financing a \$7.6 million grant for energy development since 1979. This includes energy planning, assessments, design, testing, and dissemination of 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 extra-regional sources. USAID is in the process of formulating additional assistance projects totaling about \$20 million.

Million for similar activities in the Dominican Republic, Guyana, and Jamaica, and for a follow-on project for the Caribbean regions as a whole. Already, a USAID loan of \$7.5 million has been approved to help Jamaica establish an energy program. The program's goal is to strengthen the island nation's ability to develop and carry out energy projects, expand energy conservation programs, and develop alternative energy sources.

Geothermal Power: The whole Caribbean Region is part of the Caribbean Tectonic Plate which occupies most of Venezuela and the Colombia basins. It moves east relative to both the North America Plate on its northern edge, and the South America Plate on the south (See Figure 2). 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 upward. Active volcanism around the margins of the sea and constant seismic disturbance result in continuous readjustments of the crust.

Figure: PLATE BOUNDARIES OF THE CARIBBEAN REGION

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 Bouillante 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 have been ordered.

Reports of potential geothermal energy resources in Dominica, Montserrat, St. Lucia, St. Vincent, the Dominican Republic, Grenada, Haiti, and Jamaica have been published. St. Lucia is already

The company plans to develop its thermal power source at Soufriere with units ranging from 1 to 5 megawatts. In 1969, a United Nations study was conducted in Dominica where the extensive surface manifestations made the geothermal potential quite apparent. In regard to Haiti and Grenada, it will be necessary to determine the origin of the hot springs to ascertain whether they are geochemical or geothermal before any exploratory drilling can be attempted. A feasibility study of geothermal power is currently underway for electricity generation in the Dominican Republic.

Geothermal energy does have some environmental disadvantages because gases such as carbon monoxide and traces of hydrogen sulphide are capable of polluting the atmosphere. However, this problem can be minimized with the appropriate expertise and resources. It's worth emphasizing that as of today, few attempts have been made at the utilization of geothermal energy for power generation. The major efforts have been made in the state of California, New Zealand, Mexico, and Central America.

Solar Energy: As an alternative source of energy, solar energy has received the greatest attention in recent times. 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. The average air temperature varies from about 78°F in February to 83°F in September. Nearly fifteen times more solar radiation reaches the earth's surfaces 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. Two solar stills have been built by foreign research institutes, one in Haiti and one in St. Vincent in the eastern Caribbean. These stills have been successfully providing potable water to small rural communities. Solar crop-dryers have been built in Grenada for drying nutmeg and in Guyana for chili peppers.

In Barbados, sugarcane is a major crop. Solar energy for water heating has reached satisfactory levels of development in Jamaica, Barbados, and Puerto Rico. To date, there are over 15,000 solar water heaters in residential use in Puerto Rico. The development of solar industrial steam generators and solar air-conditioned units is being pursued by the Center for Energy and Environment Research (CEER) of the University of Puerto Rico. Notable installations include a 1,100 square meter solar air-conditioned factory in Canovanas, Puerto Rico, and a new 400 square meter solar air-conditioned Post Office in Guayama, Puerto Rico.

In Barbados, passive solar designs have been utilized, with the Technical Energy Unit (TEU) building of the Caribbean Development Bank (CDB) being a prime example. Testing of this passive system is currently in progress. In addition, a solar air conditioning system has been installed and is being tested in the new Barbados Government Analyst Laboratory. USAID and the Latin American Organization for Energy Development (OLADE) are financing the design and fabrication of a solar system in Haiti at a total cost of \$9.5 million.

Ocean Thermal Energy Conversion (OTEC) is another source of untapped energy. Strong ocean surface currents pass through the Caribbean Sea from the Atlantic and continue with increasing speed through the Yucatan channel. These currents flow at an average velocity of about one mile per hour. Moreover, temperature gradients between the ocean surfaces and 1900 meter depths are more than 22°C (40°F). The maximum depth of the Caribbean Sea is 6,150 meters, approximately 160 kilometers south of Puerto Rico in the Muertos Trough. However, depths of 1,000 meters are encountered two kilometers southeast of Puerto Rico. As a result, the CEER is actively working on the development of an OTEC project on the southeast coast of Puerto Rico. In addition, Jamaica is planning an OTEC demonstration project, and the government of Holland has shown interest as well.

Proposed are three demonstration projects for Curacao, where a depth of 5,000 meters can be reached just 1,500 meters offshore. Guadeloupe and St. Croix have made preliminary evaluations of their Ocean Thermal Energy Conversion (OTEC) potential and Barbados has assessed its wave energy potential on its east coast.

Hydropower is significant in Dominica, Haiti, and the Dominican Republic. In fact, it supplies 90 percent of power generation in Dominica and 27 percent in the Dominican Republic. It could also play an important role in Guyana, Surinam, and Jamaica. In Guyana, a hydropower potential of 7,200 to 7,600 megawatts has been identified, and in Surinam, a hydropower potential of 3,000 megawatts exists. Belize is interested in mini hydro projects. A Colombian engineering firm is providing technical assistance to Haiti and Dominica to develop small-scale hydroelectric resources. El Centro La Gaviota in Colombia has developed mini hydro technologies suitable for the region.

Sugarcane is grown in many Caribbean countries, particularly in large quantities in Barbados, Cuba, the Dominican Republic, Guyana, Haiti, Trinidad and Tobago. Sugar factories in Haiti are able to meet all their energy requirements from bagasse, and in Barbados, they satisfy 90 percent of their energy needs. Bagasse is widely used as fuel for sugar mills in Guyana, Puerto Rico, Jamaica, and other countries. Firewood, charcoal, and bagasse provide an estimated 80 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 has been underway for four years at the CEER in cooperation with the Agricultural Experimental Station for the development of bagasse and tropical grasses for energy use. This program has explored the alternative use of sugarcane to produce both bagasse and the manufacturing of molasses and alcohol. It has also studied the optimization of tropical grasses for biomass production.

Bigconversion Biogas is produced when organic wastes such as 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 55 to 65 percent methane (CH₄), 35 to 45 percent carbon dioxide (CO₂), and traces of oxygen, nitrogen, and hydrogen sulphide. It is combustible with a calorific value of 20,000 to 25,000 kilojoules per cubic meter and 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. The liquid can be extracted for irrigation. A 1,000 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 algae is also grown as a feed supplement for the pigs. For example, it has been estimated that the manure from one large dairy cow could yield 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, the 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 a biogas demonstration unit. Barbados has set up three biogas digestors on their island. Puerto Rico is now designing one large unit to use animal wastes, and the Bacardi Corporation has installed a 3.5 million gallons anaerobic digester tank to treat their distilleries' residue wastes before dumping into the ocean. The disposal of municipal wastes becomes a more serious problem every year because of the continued urbanization of the Caribbean.

Countries. It may be possible for municipal waste to make a substantial contribution to solving both the energy and waste problems by converting the latter into biogas for energy use. San Juan, the capital of Puerto Rico, has plans for such efforts and has also been investigating the methane potential of its current land disposal sites.

Wind energy is the main subject of this seminar, and consequently, some aspects of it will be discussed more extensively. The northeast trade winds prevail over the Caribbean sea. The winds blow consistently from the east or northeast more than 70 percent of the time at mean velocities of about 10 miles per hour. Because of this favorable condition, a 200 kilowatt wind power generator was installed by the U.S. Department of Energy (DOE) on the island of Culebra in Puerto Rico. This energy machine is currently being evaluated.

Several of the Caribbean Islands show great suitability for the utilization of wind energy. The Caribbean has had long experience in using wind as a source of energy. Boats have been powered by wind for many years. Prior to the introduction of machinery for crushing sugarcane, small factories were situated on elevated land in order to use the available wind for driving windmills to crush the cane. This is true for Jamaica, Antigua, Puerto Rico, and Barbados.

In Antigua, the Rockefeller Foundation has financed a 12 kilowatt windmill generator. Also, a proposal for two pilot wind generators (5 to 100 kilowatt) has been sent to the United Nations Interim Fund. The Barbados-based Caribbean Meteorological Institute is an active participant in collating information about wind speeds in the Caribbean Region. A wind turbine generator factory has been installed in Puerto Rico by the Future Energy R&D 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

topics. A brief discussion of each of these topics follows:

1) Noise Effects: The noise produced by large wind turbine generators is the most objectionable environmental effect. The 2000KW wind turbine generator, known as the MOD=1 model, was developed by the U.S. Department of Energy and first operated in Boone, North Carolina, in 1980. During the operation of the machine, there were certain periods (1 percent of the time) when a sound amplification or focusing problem raised the noise level to values of up to 77 decibels. This is equivalent to twice the noise level experienced at a busy metropolitan intersection. Some people allegedly became ill and cows were said to have stopped giving milk. In order to reduce the noise level, the rotor speed was reduced from 35rpm to 23rpm by modifying the gear reduction box. This apparently has solved the problem.

It should be kept in mind that wind turbines are located in quiet country surroundings and that a little noise may be considered a nuisance to local residents. Efforts must therefore be made to define standards of acceptable noise levels for these environments and then to develop adequate computer programs to predict the noise level of planned wind turbine generators.

2) Radio Interference Effects: The rotation of wind turbine blades generates radio-frequency noise which may interfere with TV reception. The MOD-1 machine mentioned earlier produced serious TV interference for miles around, raising the objections of nearby residents. The whirling steel blades of the MOD-1 machine in Boone, North Carolina interfered so much with television reception that the area was wired for cable television. There are various solutions to this problem depending on the local situation. These solutions include:

- a) The use of Cable TV, however, this is only economical in high population density areas.
- b) The use of translators for changing from VHF to UHF, which works well in sparsely populated areas.
- c) The use of high performance antennas, as these antennas will pick up a stronger signal from the transmitting TV.

Station. The signal-to-noise ratio is larger, and the electronics can work properly. However, the cost of the antenna is high.

3) Air disturbance and reduction of wind power in nearby private properties: The wind flow pattern is altered by the presence of a wind turbine machine. At optimal operating conditions of the turbine, the effect might be felt as far as 15 diameters from the hub.

For example, in the original MOD-0 and MOD-1 machines, the windmill faced away from the wind, and the tower created a wind shadow that caused an uneven flow of air to the blades. This has been corrected in the new MOD-1 and MOD-2 wind machines where the blades face the wind. For a 300ft. diameter rotor machine like the MOD-1 2000KW machine, the effect will be felt for a distance of 4800ft. This could affect a neighboring wind turbine.

4) Aesthetic effects: Wind turbines can present an objectionable sight when located near sophisticated residential areas. For instance, the mayor of Desert Hot Springs in California has objected to Southern California Edison's plan to build a forest of wind machines there, claiming, "It will create a visual blight, and it has the possibility of destroying our tourism base."

All environmental impacts of wind turbines appear to be insignificant when compared with other energy sources. Consequently, more than 100 US electric utility projects are considering wind power. Southern California Edison is already testing wind machines in the San Geronimo Pass, and it 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 twenty-four megawatt wind turbines on Oahu by 1985. Wind Farms, Inc. has persuaded Pacific Gas & Electric Co. to buy as much as 350 megawatts of wind power. Also, three 2.5 megawatt wind turbines (MOD-2) are operating at Goodnoe Hills, Washington for the Bonneville Power Administration. The turbine's blades are each 300 feet long; the towers are 200 feet tall.

Blades rotate at 17.5 rpm. MAN in Germany is engineering and constructing a Growing (Grosse Wind Energien Lage) 3 megawatt wind energy machine! Wind appears as one of the most promising energy alternatives for the Caribbean Region. Coastal winds could be of significance 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's not forget that any activity of man causes some kind of impact on the surrounding. The aim in developing renewable energy technologies is to look for socially desirable, economically viable and ecologically prudent man-made production systems, paradigmatically inspired by the concept of ecosystem, and capable of jointly supplying human necessities.

Environmental appears in this perspective as a resource potential to be harnessed on a sustainable basis and, as much as possible, in an ecologically benign manner. We are thus recommending the eco-development approach for renewable energy technologies utilization including wind power.

Caribbean renewable energies development and potentials are summarized in Table 2. It is important that these renewable energies be examined in the light of four basic forms of energy use, namely: liquid transport fuels, centralized electric power, decentralized power, and heat. These are outlined in Table 3, "New and Renewable Energies Technologies and Applications", prepared for the United Nations Conference on New and Renewable Source of Energy.

Among new and renewable energy technologies, minihydro, small-scale solar and biomethanation are already feasible and available for rapid proliferation in a decentralized mode. They can all be used in the Caribbean Region.

Table 4 summarizes present demonstration projects in renewable energies in the Caribbean Region.

Caribbean Region. More details of some of these projects are given in the "Energy Resources in the CDCC Member Countries" report. Large scale hydro, geothermal, and to some extent, ocean power will continue to play important roles in centralized networks which principally benefit urban areas.

The prospects for biomass and peat technologies such as the production of solid, liquid and gaseous fuels are of considerable interest, providing that there are no conflicts with food production. Small-scale solar technologies for water pumping and distillation, 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 its wind potential and how soon it 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. In order to do the necessary assessments, development and demonstration projects, human resources in the Caribbean must be trained and regional programs established utilizing existing institutions in the Caribbean.

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Page § ABBREVIATION AND ACRONYMS

'Agency for International Development

British Development Division of the Ministry of Overseas Development. U.K. Government

Caribbean Development Bank

Canadian International Development Agency

Consejo Nacional de Ciencia y Tecnologia, México

Department of Energy (U.S.)

European Development Fund

European Investment Bank

International Bank for Reconstruction and Development (World Bank)

Inter-American Development Bank

National Air Space Administration (U.S.)

Organization of American States

Latin American Organization for Energy Development

Puerto Rico Electric Power Authority

Technical Energy Unit Interim-Fund

United Nations Interim-Fund

United Nations Development Program

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United Nations International Children's Emergency Fund

United States Agency for International Development