CERAXA6 November 1979 OPPORTUNITIES FOR TECHNICAL COOPERATION IN THE DEVELOPMENT OF ENERGY ALTERNATIVES IN THE CARIBBEAN AREA by Dr. Juan A. Bonnet, Jr., Director, Center for Energy and Environment Research, University of Puerto Rico. Presented at Technical Congress for Investigation and Conservation of Energy Resources, November 7-9, 1979, San Juan, Puerto Rico.

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ABSTRACT: A brief background of the Caribbean Region, including history, cultural and linguistic diversity is given along with a discussion of their dependence upon imported petroleum and tremendous economic restraints. The hope for solving their energy problems rest on utilization of their common geographical and ecological situations. Extensive natural energy resources exist in the area in the form of solar radiation, ocean currents and thermoclines, wind, geothermal formations and even hurricanes. These energies must be redirected to meet human needs. A discussion of different energy efforts presently ongoing in the region precedes a detailed account of new opportunities for technical cooperation. It is recognized that cooperation has to be based on well identified common interest areas, with the promise of recognizable results and a large

Active roles for each island. Different approaches to meet these objectives are suggested.

INTRODUCTION

In order to understand the energy options available to the Caribbean Community, we must first understand some of its characteristics. During the recent conference on Caribbean Trade, Investment, and Economic Development held in Miami, U.S.A., the President of Costa Rica, Hon. Daniel Oduber Quirós, stated that the Caribbean Community includes all the West Indies, Central America, and the Caribbean Coast of South America (Oduber Quirós, 1978). In other words, all lands in contact with the 1,049,500 sq. mi. suboceanic basin known as the Caribbean Sea. Fortunately, this paper deals only with the Island Communities in the Caribbean Regions.

The Carib Indians territorialized the Lesser Islands in the period 1000-1500 A.D. The Caribs were fierce fighters and consequently, their territory was not conquered until the mid-17th century. From then on, the Islands became pawns in the struggles among the French, English, Dutch, Spanish, and Danes. It is significant that every major European war in the 18th century was reflected in heavy fighting in the Caribbean Regions and every peace treaty included the transfer of West Indian Islands. These historical events have created a diversity of cultures, traditions, languages,

and loyalties which have for many years prevented effective direct communication and cooperation among the Islands, a situation which continues even now after many of the Islands have obtained self-government.

However, as reported in Puerto Rico and the Sea (Commonwealth of Puerto Rico, 1979): "The Caribbean Sea should be regarded as a possession common to all of the countries of the areas". There is a strong historical tendency to look toward the mother country for guidance, and of course, technology transfer. However, Islands are not chips off a mainland block but unique entities with their own priorities. Stated in other terms, "Ocean islands are not

mainlands in miniature."

"More than a cat is a miniature tiger" (Beller, 1973). For example, electric utilities depend on foreign technology for their systems. French islands have French equipment, and former British colonies have equipment from Britain or other Commonwealth countries, etc. Consequently, a mixture of 120 volts, 220 volts, 50 cycle and 60 cycle systems is found throughout the region. In short, the region uses not what it really needs, but what it inherited. Unfortunately, all islands, with the exception of Trinidad-Tobago and partly Barbados (about 30 percent self-sufficient in petroleum), almost exclusively depend on foreign petroleum. This has greatly impacted the balance of payments, employment, and development plans of the islands.

PRESENT ENERGY OVERVIEW

It was reported at the First Caribbean Conference on Energy for Development held in San Juan, Puerto Rico, that energy demand in the Caribbean from 1950 to 1965 grew at an annual rate of 8.6 percent, compared with 3 percent for the United States. The rate of increase from 1965 to 1980 is expected to be 8.4 percent. With imported petroleum fuel bills equal to 15 to 20 percent of GNP in some countries, some analysts have privately predicted that a few islands may soon face critical energy-related international monetary problems.

The 1973 oil price rise and subsequent increases hit the region hard. As an example, the new prices (June 1979) will probably raise the fuel bills of most consumers by an average of about 16 percent per year, which brings the total price rise to more than 50 percent so far this year (New York Times, 1979). In the Caribbean, a large amount of imported petroleum is used by the utility companies (see Table I).

FIGURE 1: The Price of OPEC Oil

Estimated price $22 per barrel

1979 OPEC average quarterly price for crude oil in dollars per barrel

Prices are for the end of the quarter

Source: Energy Department, The New York Times, June 29, 1979

Hi,

The capacities range from less than 10 megawatts to several hundred megawatts. Cuba and Puerto Rico, with 1705 and 4338 megawatts of installed capacity respectively, have the larger electric power systems. Currently, as reported by Donovan, Hamester, and Rattien, Inc. (Donovan, et al, 1979), no utility company in the Antilles has an alternative energy program which involves solar energy. At present, alternative energy programs are only at the academic or science council level. Only Cuba is presently pursuing the nuclear energy option.

The commercial sector's demand for electric energy in the smaller islands - which are frequently dominated by the hotel industry - accounts for as much as sixty percent of all electrical energy consumed. Residential electric energy consumption accounts for an additional twenty percent. Unless new energy alternatives are sought and developed, petroleum-based fuels will continue to be the main energy source for electricity and transportation. This situation could adversely affect the tourist industry. The energy crisis is restricting people's flexibility and mobility.

As the Energy Users News mentions (Energy Users News, 1978), there is "No honeymoon in the Caribbean as Energy Costs Soar". It shows as an example, already last year the cost of generating electricity on Saint Lucia reached 9.5 cents per kWh. The average electric cost in Puerto Rico is 7.6 cents per kWh. In order to gain time, energy conservation measures must be taken immediately by the energy users and producers.

However, the ethics of emphasizing energy conservation versus energy alternatives for Third World countries was amply discussed during the Tenth World Energy Conference (1977). Many Third World representatives stated that if a country does not have energy to develop itself, it cannot conserve. The general feeling was that Third World countries must emphasize the development of energy alternatives suitable to their needs.

7. ENERGY CHOICES

Geology and Seismology

To solve the energy

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West Coast (Nest Indies and Caribbean Year Book, 1978). This has been capped, and as pressure is considered to be sufficient to operate two geothermal electricity generating stations, the necessary plant and equipment has been ordered.

Ocean Thermal Energy Conversion: Tidal movements in the Caribbean Sea are small, partly because of the enclosed nature of the region. The tides range up to two feet but averages only one foot. Surface ocean currents pass strongly through the Caribbean Sea from the Atlantic and continue with increasing speed through the Yucatan channel. The main current flows at an average velocity of about one mile per hour. Also, temperature gradients between the ocean surface and 1000 meters depth are more than 40°F (22°C). Great sources of untapped energy exist in these currents and temperature gradients. The maximum depth of the Caribbean Sea, South of Puerto Rico, is 6150 Meters, about 160 km offshore in the Muertos Trough. However, at 2 km Southeast of Puerto Rico, depths of 1000 meters are already encountered. Consequently, Puerto Rico is actively working on the development of Ocean Thermal Energy Conversion (OTEC).

Wind Energy: The Northeast trade winds prevail over the Caribbean Sea. The winds blow consistently from the East or Northeast more than 70% of the time at mean velocities of about ten miles per hour. Because of this favorable condition, a 200 kilowatt wind power generator has been installed by the U.S. Department of Energy on Culebra Island and this energy source is being evaluated.

Solar Radiation: The solar radiation in the Caribbean Region is on the order of 2000 kwh/meter2/year. Average air temperature varies from about 78°F in February to 83°F in September. Sunlight and mild temperatures are two valuable assets of the tourist industry and the first is also a great diffuse energy resource. As an..."

Example: Barbados received 426 times the amount of commercial energy consumed in 1977 in solar energy (Cox, 1978). However, the Caribbean region is generally visited by hurricanes from August to October yearly, which results in lower solar irradiation during these periods. The Caribbean region faces some very difficult energy choices with solar, geothermal, wind, ocean currents and gradients. Hydrocarbons are also present in some offshore areas. A few decades from now, we may also tap the energy of volcanoes and tropical storms. A geopolitical circumstance now widely known is that, historically, close to two-thirds of all United States oil imports (crude as well as products) have been moved there by way of installations established in the Caribbean Area (Governor, Netherland Antilles, 1978). (See Table 11). However, the recent U.S. policy of decreasing oil dependency could mean a fundamental readjustment or an eclipse for the Caribbean refining industry. On the other hand, with little capital, few trained technicians, scanty infrastructure, inadequate reserves of conventional fuels (with the exception of Trinidad-Tobago) and small land masses with generally rapidly growing populations, there is little margin for error. Small is beautiful, but very expensive.

Table 11. Petroleum Refining Capacity in the Caribbean (Oil and Gas Journal, 1976)

Country - Exported Refinery - Operated by - Capacity (000 6/4)

Venezuela - Lagoven/Exxon (at Amuay) - 600

Venezuela - Maraven/Shell (at Carbon) - 337

Netherlands Antilles - Exxon (at Aruba) - 440

Netherlands Antilles - Royal Dutch Shell (at Curacao) - 409

Trinidad and Tobago - Texaco (at Point-a-Pierre) - 361

Trinidad and Tobago - Trintoc/Shell (at Point Fortin) - 00

U.S. Virgin Islands - New Amerada Hess Corp. (at St. Croix) - 728

The Bahamas - New England Petroleum Co. - 500

Standard Oil of California and Texaco (at Colon) - 100

Puerto Rico - CORCO (at Guayanilla) - 161

Puerto Rico - Sun Oil Co. (at Yabucoa) - 88

Caribbean Gulf (at Catano) - 40

TOTAL... 3,864

As mentioned by Eugene C. Cronmett (Cronmett, 1975), the

The resources of the Ocean Islands are not only vulnerable, but they are also very limited. Due to their isolation and small size, islands can be classified into one of two types: those which depend upon agriculture and fishing, and those which depend upon commerce and industry. The former is usually poorer economically, and, with the exception of Trinidad and Tobago, all the Lesser Antilles fall into that category. So, how then, can we work together to help solve the common energy dependence?

Efforts are already underway to collectively analyze the Caribbean energy situation. Unfortunately, very little energy data is currently available in the Caribbean Region. Various conferences have been held. At the Project Group Meeting on Alternative Energy Resources from September 18-22, 1977, Barbados was one of the few that indicated efforts made in this area.

The objectives of the Barbados meeting were to review the current state of activities of alternative energy resources and to assess small scale energy needs in the region; to identify specific projects for collaboration; and to draft joint project proposals for such collaboration. As a result of the meeting, specific projects were identified in areas such as Biogas, Bagasse, Data Acquisition, Solar Systems, Wind Systems, Integrated Energy Systems, Biomass, Conservation, Wave Energy Resources, and Electric Vehicle Development.

Also, a Steering Committee was formed under the direction of the Caribbean Commonwealth Council (Commonwealth Science Council, 1977) to promote and pursue the implementation of these proposals.

It is apparent that during this meeting, significant attention was given to the National Academy of

Sciences Publication "Energy for Rural Development" (National Academy of Science, 1976) recommendations on energy alternatives. The NSF report concluded that:

1. A variety of energy resources and technologies are indeed available as alternatives to conventional power systems.
2. With the exception of a few devices, there are no

Cheap alternative technologies of significance for either industrialized or developing nations are not currently available, and it is unlikely there will be any in the near future. It is not enough for an energy resource to be available; the technology to utilize it must also be present.

The following activities were proposed by the National Science Foundation as steps toward a solution to the energy problem:

1. Organization of workshops to evaluate the potential role of decentralized power systems for rural areas in developing countries.
2. Organization of a pilot energy-oriented development program to assist rural areas in acquiring the needed energy technology and the means to exploit it usefully.
3. Establishment of regional institutes for research and development of technologies for exploitation of renewable energy resources.

The workshops continued with the First Caribbean Conference on Energy for Development held on April 3-6, 1978, in San Juan, Puerto Rico. This conference was of a wider scope and included on its agenda energy supply and demand, conservation, energy in key economic sectors, and the economic and financial possibilities and constraints.

The conference was attended by more than 300 persons from 26 countries, and seven international organizations. The meeting exceeded expectations by instilling a new awareness of common as well as unique energy problems facing the countries and territories in the region.

The discussions at the conference pointed out that the Caribbean Islands should not have great hopes for oil exploration to provide an answer to their energy supply problems and should look toward other energy alternatives. Many conference attendees expressed intense interest in the use of sugar cane for alcohol and biomass production.

Following this conference, other smaller conferences have been held, such as the Caribbean Consultation on Energy and Agriculture from November 29 to December 1, 1978, in the Dominican Republic, and Energy Self-sufficiency and the Virgin Islands (Caribbean).

"Res. Inst., 1978), December 8, 1978, Workshop on Energy Accounting for the Caribbean Subregion (Commonwealth Science Council et.al., 1979) May 14-18, 1979 in San Juan, Puerto Rico. There was also an Alternative Energy Workshop (U.S. Agency for International Development, 1979) held on May 24-25, 1979 in Barbados. Similar workshops have also been held in other parts of the world. For example, the National Academy of Sciences held a joint workshop with the Government of Tanzania in August 1977 (Brown and Howe, 1978).

However, before we proceed further, a short review of the history and current programs of the Center for Energy and Environment Research (CEER) may be relevant. CEER was initiated in July

1976 at the University of Puerto Rico under the auspices of the U.S. Department of Energy. With an annual budget of over $3.5 million and approximately 200 employees, it is the largest R&D organization working on energy-related matters in the Caribbean area.

The Center has active programs (CEER Annual Report, 1978) in solar data collection and analysis, solar water heaters, solar parabolic compounded collectors for industrial process heat, and solar air cooling. Other programs are involved with biomass, sugarcane and other grasses, forestry, bioconversion, methane, alcohol, pyrolysis, desulphurization of heavy crude oils, and terrestrial, marine, and human ecology. CEER is also establishing an Energy Field Station to develop appropriate technology devices.

One of the main goals of CEER is to develop indigenous energy resources for the Caribbean Region that are compatible with the fragile tropical environment. These goals are shared with other Caribbean Institutions. The University of the West Indies, the only transnational University in the world, has been working for some years on solar research including insolation and wind energy mapping, solar agriculture, and waste conversion pyrolysis (Lalor, 1977). Another appropriate technology and development center is Las Gaviotas (Rensberg, 1979) in the..."

Llanos region of Colombia. They have built an inexpensive windmill, solar heaters, and a small stream-powered turbine. Sun World (Gardner, 1979) also recently discussed a solar-cooled building in Barbados, which was sponsored by the Commonwealth Science Council. As Mr. Rensberg (Rensberg, 1979) mentions, "There is an extraordinary new breed of inventors, scientists, and engineers beginning to emerge in the Third World". Many leaders now believe that a wiser alternative to importing technology is encouraging simpler, smaller-scale technologies designed locally and applied broadly. This approach not only meets a country's grassroots needs but also builds pride in achievement and self-reliance, which is too often disastrously sapped by imported technology and technicians.

5. In this movement, the Caribbean universities must adopt the leadership role in research and development for their own national needs.

OPPORTUNITIES FOR TECHNICAL COOPERATION

From what has already been said, it can be concluded that the willingness and the atmosphere for developing energy alternatives, following the Schumacker, "Small is Beautiful" (Schumacker, 1973), and Lovins, "Soft Energy Path" (Lovins, 1978) approach in the Caribbean region, is ideal. It will be relatively easy to convert one of the Lesser Antilles Islands to energy self-sufficiency if appropriate programs and resources are developed. As an example, the state of California is planning to be self-sufficient in energy by the year 2025, and they produce at the moment about 3,500 times the electricity that is produced in the Virgin Islands. The Virgin Islands last year produced about 460 million kWh of electricity. The Island of Culebra, with a 200 KWe wind turbine generator, is already energy self-sufficient, but only on Sundays. On weekdays, the wind turbine only provides about 20% of Culebra's needs. Consequently, the Lesser Antilles are ideal areas to test the concepts of 'small is beautiful', energy soft paths, and self-sufficiency because of their limited size.

Geographical areas have ample solar, wind, and ocean energy resources and higher cost of energy

which makes almost any of these alternatives economically competitive. As Denis Hayes (Hayes, 1977) also notes, the Third World can take the shortest path out of the fossil fuels cul-de-sac. While the industrial world has heavy investment in fossil technologies, which are hard to get rid of, they have no solar powered societies to emulate. The approach to actually ‘implement these energy self-sufficiency concepts for the Lesser Antilles

16. WITT depends heavily on the priority and effort that each Island is prepared to assign to this goal. It is indispensable to assure that whatever technology is selected meets the local needs. However, none of the islands can do it alone. Help is needed from the international community. During the First Caribbean Conference on Energy and Development at San Juan, Dr. David L. Morrison mentioned that there are usually four factors involved in technology transfer:
1. a local industry
2. a local technical institute
3. an external technical institute
4. external technology sources

He then recommended a six-part methodology for technology transfer which has been used successfully and might be applied to the Caribbean:
1. the local technical institute identifies the needs of the island,
2. the external technical institute searches for relevant technologies.
3. the local technical institute chooses the technologies.
4. the external institutes arrange an in-depth transfer between the external technology sources and the local industry.
5. the local institute demonstrates the technology.
6. the local industry manufactures and promotes the use of the end product.

However, as Colin Norman (Norman, 1978) points out, if technological development is to be more compatible with human needs, and more in harmony with the earth's resources, four principal points must be recognized. First, the unfettered working of the market system cannot be relied upon to promote the development.

The adoption of appropriate technologies is crucial, especially for the poor who, by definition, are often outside the market system. Secondly, many new technologies are inappropriate for the needs of developing countries. Thirdly, the development of new technologies requires new arrangements for sharing with the Third World. Fourthly, it must be accepted that technology alone cannot solve political and social problems. Generalizing from one society to another is challenging. Only by carefully examining the impact of new technologies on people, social systems, and the natural environment can we begin to form a picture of the appropriate technology for any particular situation.

During the recent AID Alternative Energy Workshop, goals were set to promote energy self-sufficiency in the Caribbean region by strengthening the following capabilities within the region:

1. Country energy need assessments,
2. Renewable energy resource assessment,
3. Technical analysis of alternative energy applications.

To achieve these goals, the program will provide:
1. Technical assistance to national and regional energy planning activities,
2. Technical and analytical training in energy management and energy technology development,
3. A regional communications network to collect and disseminate energy information and establish international contacts,
4. Research and field testing of renewable energy technologies.

To organize the program, DAR was contracted by AID. The objectives of the DHR study were to assess current regional activities and needs in renewable energy, design an organizational structure for a regional alternative energy program, and recommend activities for the program in policy analysis, training, communications, and hardware identification, development, and field testing.

At the workshop, DHR recommended that the following organizations take the lead in the planning, management, and direction of the Center:
1. The Caribbean Development Bank (COB)

The following text will serve to provide program management, fiscal management, and regional coordination.

1. The Caricom will serve as the policy research and development arm.
2. The Center for Energy and Environment Research (CEER) of the University of Puerto Rico will provide technical assistance for applied R&D, proposal evaluation, and project monitoring.

It was also concluded that there is a great deal of interest and a substantial amount of activity in the Caribbean, with several renewable energy technologies offering long-term, large-scale petroleum displacement potential. DAR also carried out a Caribbean Region Solar Corporation Study (Donovan et.al., 1979) for the U.S. Department of Energy.

219: The study concluded that the DOE-USA could best organize its activities to support solar energy research and development, and cooperation in the Caribbean if it can first suggest, and then help develop, a common program approach for solar energy technology evaluation and transfer for all the countries in the Caribbean interested in investigating alternative energy paths.

The recommended operational scheme attempts to retain a decentralized approach for individual countries or territories, yet creates a common procedural framework which would hopefully facilitate future cooperative efforts. The recommended approach is predicated on the following four steps to successfully introduce new technologies:

1. Development of a process to continually monitor alternative energy technological development around the world.
2. Development of an internal process that leads to the identification of the technologies that should be investigated for local use.
3. Development of procedures to evaluate and adapt these technologies.
4. Creation of a technology dissemination program that includes training and education components.

The U.S. Department of Energy should cooperate fully in this approach. DAR recommends that DOE should consider assisting an existing research institution in the Caribbean such as the Center for Energy.

Environment Research (CER) in Puerto Rico to be a partner in their role. In addition to CER, the University of the West Indies and others might become model alternative energy technology adaptation experimental stations.

Conclusion. The Caribbean Islands can cooperate internally, and with international agencies in the development of indigenous alternative energy resources suitable to their needs. That cooperation will probably have to be based on their well-identified common interest areas, have the promise of recognizing priorities on the countries, and include a large active role to be played by each country. This cooperative effort can be at different levels including government, universities, centers, science institutes, and funding agencies.

As stated in the U.S.A. Position Paper for the United Nations Conference on Science and Technology for Development, held last August in Vienna, fairness is needed along with action in the global transfer of science and technology. It suggested certain norms worth considering.

First, the transfer must be a cooperation and joint effort of Government and the private sector in which development priorities of the recipient countries are respected and in which private industries and organizations enjoy due protection and due returns on their investment and inventiveness.

Second, in order to have an effective transfer, the information base in the developing countries must be broadened to permit them to select what they need from the international supermarket of technology. They must be able to reject what they do not need, to choose among competitive offerings, and to acquire what is most appropriate and economical for their development needs.

Third, the transfer must include an increasing shift in research and development to the developing countries. Research and development

2. That are locally based and oriented toward indigenous resources, needs, and demands contribute not only to the growth of self-reliant capacities.

But, a widening of markets and technological innovations are also necessary. Fourthly, the transfer of technology must occur among the developing countries themselves. With these promises, we should be ready to extend our hands on an equal cooperative basis. The important aspect is not to react, but to act now.

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