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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

CENTER FOR ENERGY AND ENVIRONMENT RESEARCH
UNIVERSITY OF PUERTO RICO — U.S. DEPARTMENT OF ENERGY

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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 role for each Island. Different approaches to meet these objectives are suggested.

INTRODUCTION

In order to understand the energy options available to the Caribbean Coomunity 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 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 Caribbean Sea. Fortunately, this paper deals only with the Islands 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 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".

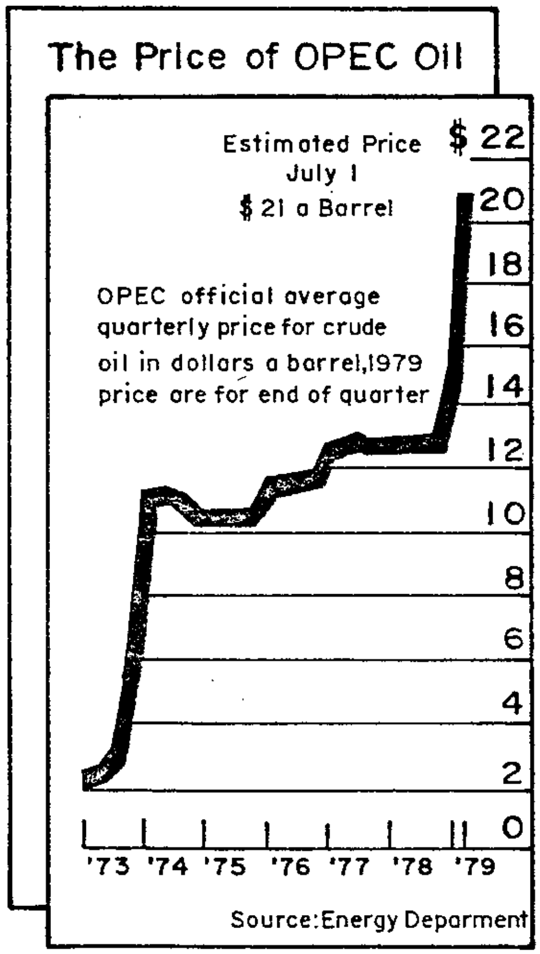
There is a strong historical tendency to look toward the mother country for guidance, and of course, technology transfer. However, Islands are not chips off a mainland block but unique entities with their own priorities. Stated in other terms, "Ocean islands are not mainlands in miniature any more than a cat is a miniature tiger" (Beller, 1973). For example, the electric utilities rely on foreign technology for their systems. The French Islands have French equipment and former British colonies have equipment from Britain or other Commonwealth countries, etc. Consequently, one finds a mixture of 120 volts, 220 volts, 50 cycle and 60 cycle systems throughout the region. In short, the region utilizes not what it really needs, but what it inherited, and unfortunately all the islands, with the exception of Trinidad-Tobago, and partly Barbados (about 30 percent self-sufficient in petroleum) depend almost exclusively on foreign petroleum. This has had a tremendous effect on 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 at 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 1965 to 1980 rate of increase 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 have critical energy-related international monetary problems. The 1973 oil price rise and subsequent increases affected the region badly. (See fig. 1). As an example, the new prices (June 1979) will probably raise the fuel bills of most consumers an average of about 16 percent a year, which carries the aggregate 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 utilized by the utility companies (See Table I) which have peak

FIGURE I



The New York Time/June 29, 1979

TABLE I - Electricity Capacity and Production in the Lesser Antilles

Island	Area (1) (Sq.Mi.)	Population (2) (Thousands)	Installed (3) Electricity Capacity (Megawatts)	Yearly (3) Electricity Production (Millions Kwhr)	Electricity Production Per Capita (Kwhr/person)	GNP (4) (Millions $US)	Electricity Production Per GNP (Kwhr/$US)
Antigua	170	71	22	47	662	50	0.94
Bahamas	5380	211	255	600	2843	700	0.86
Barbados	166	247	99	228	923	400	0.57
Bermuda	20	57	85	310	5439	440	0.70
Cuba	42827	9464	1705	7198	761	7720	0.93
Dominica	290	77	6	15	195	30	0.50
Dominican Republic	18703	4835	743	2690	556	3820	0.70
Grenada	120	96	7	28	292	50	0.56
Guadalupe	680	360	50	190	528	770	0.25
Haiti	10714	4668	89	209	45	1020	0.20
Jamaica	4411	2057	685	2378	1156	2390	0.99
Martinique	425	369	55	194	526	1070	0.18
Monserrat	39	12	4	9	750	NA	NA
Netherland Antilles	384	241	290	1600	6639	430	3.72
Puerto Rico	3435	3213	4338	17150	5338	7400	2.32
St. Kitts-Nevis	65	66	13	23	348	30	0.77
St. Lucia	238	110	14	45	409	60	0.75
St. Vincent	150	106	9	17	160	30	0.57
Trinidad-Tobago	1864	1098	454	1367	1245	2400	0.57
Virgin Islands(U.K)	59	12	4	12	1000	NA	NA
Virgin Islands (U.S.)	136	98	239	720	7347	490	1.47

NA - Not Available

(1) Caribbean Year Book 1978-79. Caribook Limited, Toronto.
(2) Demographic Yearbook/Annuaire Demographique 1976. United Nations Department of Economic and Social Affairs.
(3) World Energy Supplies 1972-1976. United Nations Department of Economic and Social Affairs. Statistical Papers Series 3 No. (1976 Data).
(4) 1978 World Bank Atlas: Population, Per Capita Product and Growth Rates (1976 Data).

capacities that range from less than 10 megawatts to several hundred megawatts. Cuba and Puerto Rico with 1705 and 4338 megawatts of installed capacity have the larger electric power systems. At present, 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 at present 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 badly affect the tourist industry. The energy crisis is taking away people's flexibility and mobility. As the Energy News mentions (Energy Users News, 1978), there is "No honeymoon in the Caribbean as Energy Costs Soar", and it shows as an example, already last year the cost of generation electricity on Saint Lucia reached 9.5 cents per Kwh. The average electric cost in Puerto Rico is 7.6 cents per Kwh.

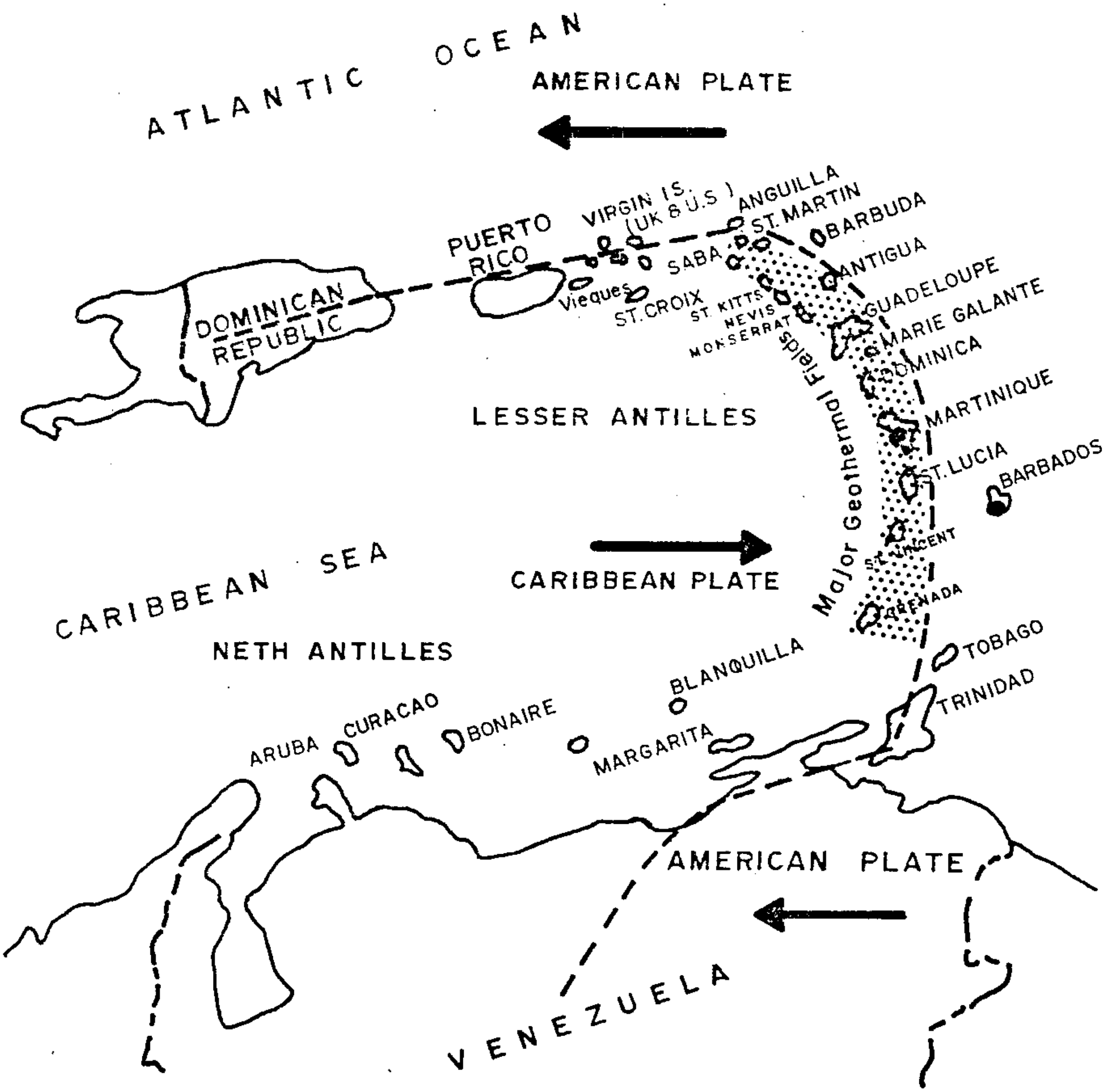
In order to gain time, energy conservation measures must be taken immediately by the energy users and producers. However, the ethics of emphasizing energy conservation versus energy alternatives for Third World countries was amply discussed during the Tenth World Energy Conference (1977). Many Third World representatives stated that if a country does not have energy to develop itself it can not conserve. The general feeling was that Third World countries must enphasize the development of energy alternatives suitable to their needs.

ENERGY CHOICES

Geology and Seismology

To solve the energy problems in the Antilles we must recognize that there are large amounts of natural energy in the area. There seems to be only one factor which gives hope for establishing a constructive and common basis to solve the energy dilemma of the Antilles: their common geographical and ecological situation inherited from nature. The whole area is part of a Caribbean Plate (Western Geophysical, Inc., 1974), occupaying most of the Venezuela and Colombia basins, moving East relative to both the North American plate on its Northern edge, and the South American plate on the South. (See figs. 2 to 4). Recent volcanism and the smooth arcuate pattern of the Islands, as well as historic earthquakes patterns, prove that the Lesser Antilles is a true modern Island Arc. Also the northern Lesser Antilles is separated into an inner and outer arc - the Leeward and Windward Islands-with the northernmost Islands mostly underlain by a carbonate terrace. Actually the entire Caribbean area appears to have been extensively intruded by large bodies of basaltic magna which developed deep within the mantle of the Earth and moved upward. Active volcanism around the margins of the sea and constant seismic disturbance represent continuous readjustments of the crust. Regions of geothermal reservoirs are generally localized along the margins of major crustal plates and the Lesser Antilles is recognized as one of these zones (Muffler and White, 1972). (See figs. 2 to 4). A tremendous waste of energy in these areas is from volcanism eruptions, with large amounts of hot (700°C to 1300°C) magna being extruded through the crust from the mantle. Volcanos exist in the French Lesser Antilles. Martinique has the presently inactive volcano Mont Pelee, and in Guadaloupe a vein of steam connecting with La Souffriere volcano has been tapped by drilling at Bouillante off the

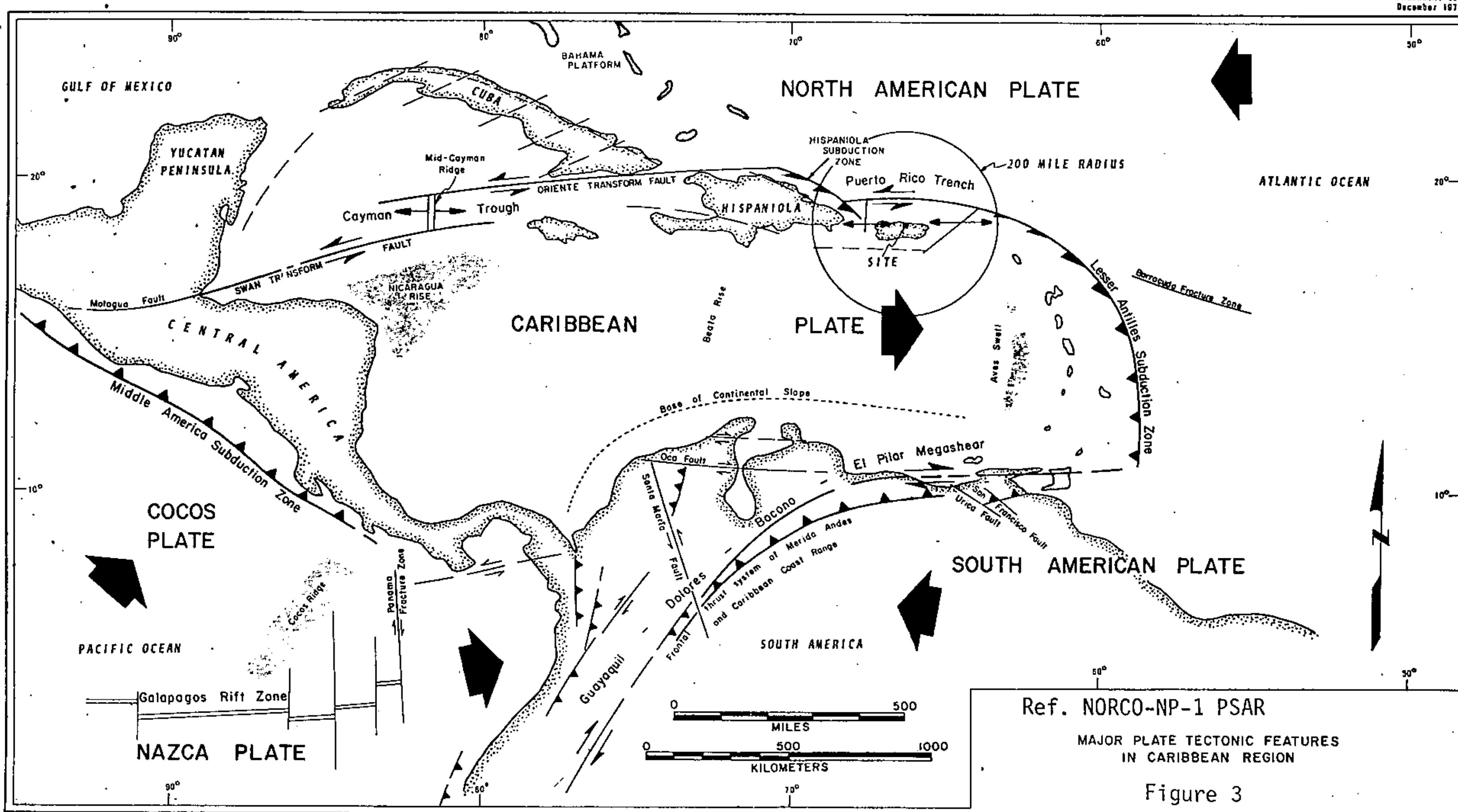
FIGURE 2



MAJOR GEOTHERMAL FIELDS IN THE
LESSER ANTILLES OR CARIBBEAN ISLANDS

.8A.

Amendment 30
December 1975



Ref. NORCO-NP-1 PSAR

MAJOR PLATE TECTONIC FEATURES IN CARIBBEAN REGION

Figure 3

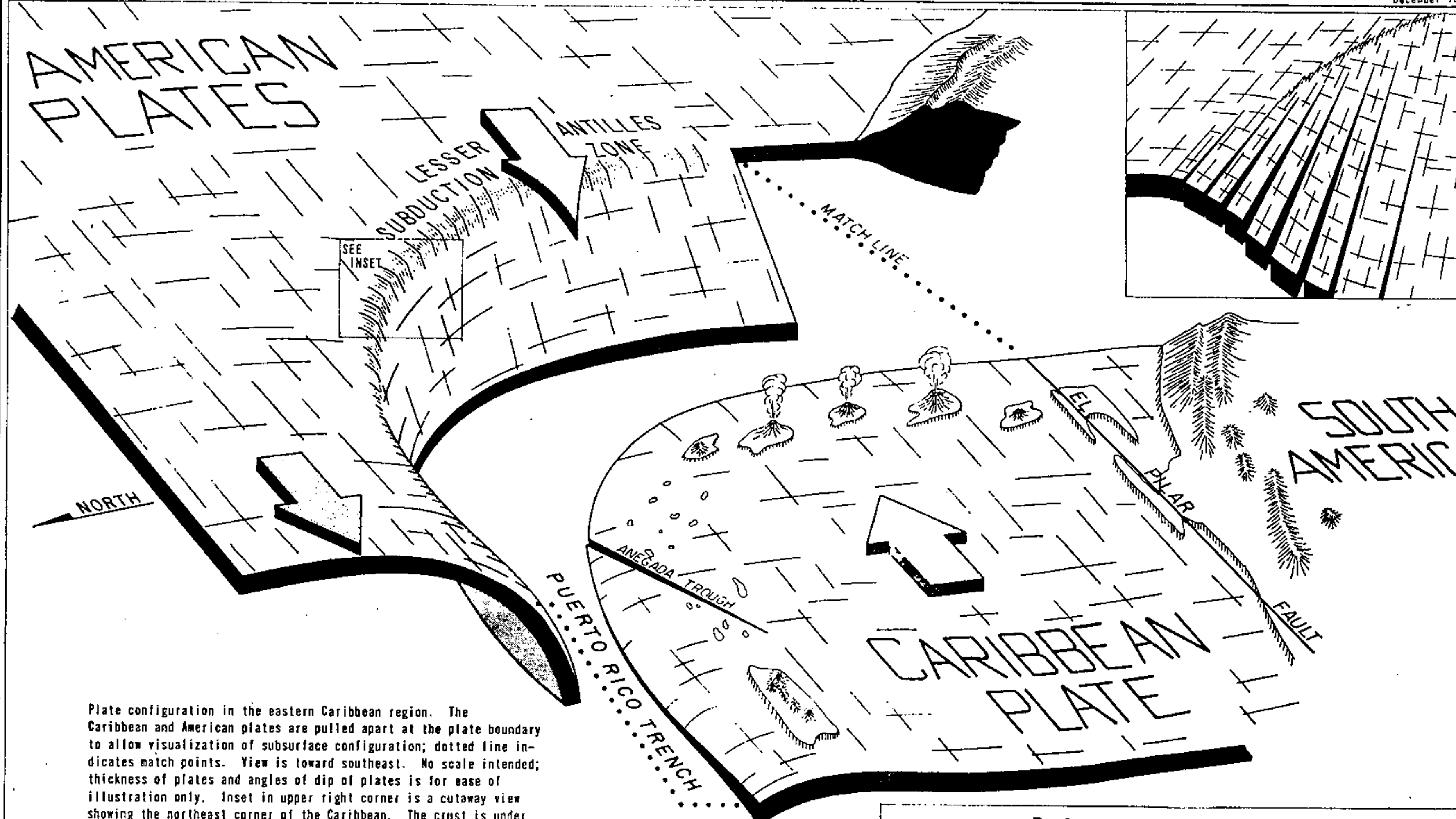


Plate configuration in the eastern Caribbean region. The Caribbean and American plates are pulled apart at the plate boundary to allow visualization of subsurface configuration; dotted line indicates match points. View is toward southeast. No scale intended; thickness of plates and angles of dip of plates is for ease of illustration only. Inset in upper right corner is a cutaway view showing the northeast corner of the Caribbean. The crust is under considerable tension there as it is bent and stretched causing separation into numerous blocks. The deep blocks are consumed under the Lesser Antilles but the shallower blocks continue westward under the Puerto Rico-Virgin Island area.

Ref. NORCO-NP-1 PSAR

PLATE CONFIGURATION IN EASTERN CARIBBEAN

Figure 4

West Coast (West Indies and Caribbean Year Book, 1978). This has been capped, and as pressure is considered to be sufficient to operate a geothermal electricity generating station, 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/meter^2/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 in solar energy, 426 times the amount of commercial energy consumed in 1977 (Cox, 1978). However, the Caribbean region is generally visited yearly by hurricanes from August to October which results in lower solar irradiation during these periods.

Oil and Other Aspects

The Caribbean region faces some very difficult energy choices with solar, geothermal, wind, ocean currents and gradients. In some offshore areas hydrocarbons are also present. A few decades from now we may also tap the energy of volcanos 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) has been moved there by way of installations established in the Caribbean Area (Governor, Netherland Antilles, 1978). (See Table II). However, the recent U.S. policy of decreasing oil dependency could mean fundamental readjustment or an eclipse for the Caribbean refining industry. On the other hand with little capital, few trained technicians, scanty infra-structure, 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 II. Petroleum Refining Capacity in the Caribbean (Oil and Gas Journal, 1976)

Country	Exported Refinery Operated by	Capacity (000 b/d)
Venezuela	Lagoven/Exxom (at Amvay) Maraven/Shell (at Carbon)	600 337
Netherlands	Exxom (at Aruba)	440
Antilles	Royal Dutch Shell (at Curacao)	409
Trinidad and Tobago	Texaco (at Point-a-Pierre) Trintoc/Shell (at Point Fortin)	361 100
U.S. Virgin Islands	New Amerada Hess Corpo. (at St. Croix)	728
The Bahamas	New England Petroleum Co. Standard Oil of California	500
Panamá	Texaco (at Colon)	100
Puerto Rico	CORCO (at Guayanilla) Sun Oil Co. (at Yabucoa Caribbean Gulf (at Cataño)	161 88 40
	TOTAL....................	3,864

As mentioned by Eugene C. Crommett (Crommett, 1975) the resources of the Ocean Islands are not only vulnerable, but they are very limited. Due to their isolation and small size, islands can be classified as 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-Tobago, all the Lesser Antilles are of that category. How then, can we work together to help solve the energy dependence common to all?

ENERGY EFFORTS UNDERWAY

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

The objectives of the Barbados meeting were to review the present 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 System, 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 wide 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, and there probably will not be any in the near the future.

3. It is not enough that an energy resource be available; the technology to put it to use must also be present.

The following activities were proposed by the National Science Foundation as steps toward a solution of 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 succeeded beyond 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, November 29 to December 1, 1978 in the Dominican Republic, Energy Self-sufficiency and the Virgin Islands (Caribbean Res. Inst., 1978), December 8, 1978, Workshop on Energy Accounting for the Caribbean Subregion (Commonwealth Science Counsel et.al., 1979) May 14-18, 1979 in San Juan, Puerto Rico, Alternative Energy Workshop (U.S. Agency for International Development, 1979) May 24-25, 1979 in Barbados. Similar workshops have also been held in other areas 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).

Digressing momentarily from the topic, a short review of the history and present programs of the Center for Energy and Environment Research (CEER) may be pertinent at this time. CEER was initiated in July 1976 at the University of Puerto Rico under the auspicies of the U.S. Department of Energy. With an annual budget over $3.5 million and approximately 200 employees, it is the largest R&D organization working in 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. Others programs are involved with biomass, sugarcane and other grasses, forestry, bioconversion, methane, alcohol, pyrolisis, 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 which 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. Also Sun World (Gardner, 1979) 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". A wiser alternative to importing technology, many leaders now believe, is encouraging simpler, smaller-scale technologies designed locally and applied broadly. This approach not only meets a country's grass roots needs but also builds pride in achievement and self reliance which is too often disastrously sapped by imported technology and technicians.

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 Virgin Islands.

The Virgin Islands last year produced about 460 millions kwh of electricity. The Island of Culebra with a 200 KW_e 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 <u>Lesser Antilles are ideal areas to test the concepts of small is beautiful</u>, <u>energy soft paths</u>, <u>and self-sufficiency</u> because of their limited geographical areas, amples 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 will depend 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 choose the technologies.
4. the external institutes arrange an indepth transfer between the external technology sources and the local industry.
5. the local institute demonstrate the technology.
6. the local industry manufactures and promote 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 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 and adoption of appropriate technologies, for the simple reason that the poor, by definition, are often outside the market system. Second, many new technologies are inappropriate to the needs of the development countries. Third, the development of new technologies require new arrangements for sharing with the Third World. Fourth, it must be accepted that technology, by itself, cannot solve political and social problems.

It is very difficult to generalize from one society to another. Only by paying careful attention to the impact of new technologies on people, social systems, and the natural environment will the picture of an appropriate technology for any particular situation begin to emerge.

During the recent AID Alternative Energy Workshop, goals were established to promote energy self-sufficiency of the Caribbean region by strengthening the capability within the region for:

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

Toward this purpose, 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. Regional communications network to collect and disseminate energy information and to establish international contacts.
4. Research and field testing of renewable energy technologies.

In order to organize the program DHR was contracted by AID. The DHR study objectives were to assess current regional activities and needs in renewable energy, to design and recommend an organizational structure for a regional alternative energy program, and to recommend activities to be performed by the program in policy analysis, training, communications and hardware identification, development and field testing. DHR recommended at the workshop that the following organizations take the lead in the planning, management and direction of the Center:

1. The Caribbean Development Bank (CDB) will serve to provide program management, fiscal management, regional coordination.
2. The Caricom will serve as the policy research and development arm.
3. 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.

They also concluded that there is a great deal of interest and a substantial amount of activity in the Caribbean and that several renewable energy technologies offer long term, large-scale petroleum displacement potential.

DHR also carried out a Caribbean Region Solar Corporation Study (Donovan et.al., 1979) for the U.S.A. Department of Energy. The DHR 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 held 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 operational scheme recommended 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 internal process that leads to identification of the technologies that should be investigated for local use.
3. Development of procedures to evaluate and adapt those technologies.
4. Creation of a technology dissemination program that includes training and education components.

The U.S.A. Department of Energy should cooperate fully in this approach. DHR recommends that DOE should consider assisting an existing research institution in the Caribbean such as the Center for Energy and Environment Research (CEER) in Puerto Rico to be a partner in their role. In addition to CEER, 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 probably will have to be based on their well-identified common interest areas, have the promise of recognizing priorities on the countries, and including a large active role to be played be each country. This cooperative effort can be at different levels including government, universities, centers and/or science institutes and funding agencies.

As the U.S.A. Position Paper for the United Nations Conference on Science and Technology for Development, held last August in Vienna, specified 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 development 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 that are locally based and oriented toward indigenous resources, needs, and demands contribute not only to the growth of self-reliant capacities but to a widening of markets and technological innovations as well.

Fourth, the transfer of technology must also 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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