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THE ENERGY ALTERNATIVES FOR THE CARIBBEAN

by

Dr. Juan A. Bonnet, Jr, Director

Prosented at Seminar on

WIND AS AN ENERGY ALTERNATIVE FOR THE CARIBBEAN

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Bri¢getoun, 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 U9S34 a barrel, but it also decided to freeze this basic price until Decomber 1982, thus protecting poorer countries from unex

pected and wi

wanageable increases!

Yet, unless long range steps are taken soon, the OPEC action may not be enough. Nearly 100 developing countries depend on vil to meet more than sixty percent of their energy needs. Most of them import four-fifths of their total oi! requirements, The price of oil, in inflation-adjusted terme, has quintupled over the past decade (See figure 1), and many analysts prediet price in-

Wes of three percent annually, This means the poor countries are now spending $50 billion a year to pay for imported oi! and vaying $110 billion a year by 1990,

To offset this economic drain, many countries are turning to

they could be

the most readily available alternative supply. Forty percent of the developing world?s timber reserves may Merally go up in

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Borrel

US. Dollars

a

a

Figure |

OILS PRICES, ANNUAL MEANS

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smoke, as households and small industry substitute firewood for oll, In a number of Caribbean countries exploitation of wood resources is not in equilibrium with regeneration rates. Wood and charcoal meet a large part of Haiti's energy requirements and in a lesser degree of countries with forest reserves such as Belize, yyana and St. Lucia.

While developing countries contain two-thirds of the world's

Dominican Republic, Grenada, Gi

population, they account for only one-seventh of world energy's production. The success that developing countries achieve in re-Gucing their dependence on imported energy will determine, in they will have in manag~
Since the Arab oil embargo of

large measure, the degree of flexibility

ing their economies in the future.
1974, the debt of developing countries has more than quadrupled to £425 billion, causing more of their income to go for debt ser vice at continuously increasing rates of interest.

The World Bank estimates that up to 30 percent of the Geveloping world's energy needs could be eliminated around 1990 by maximising conservation efforts and by increasing energy production from fuel sources such as oil, gas, coal, hydropower and renewables. It has outlined ways of reducing those energy

needs by 15 percent without sacrificing economic growth during the coming decade.

During this year there has been an increase of discussion about energy?. Last November, south and north countries, telked about energy at the Cancum, Mexico Summit Meeting. Before this in August there were many discussions about renewable energy at the United Nations Conference on New and Renewable Sources of Energy in Nairobi?, For months there have been discussions about 4 World Bank proposal to set up a separate energy affiliate within the bank, but up to now no concrete agreements have been reached.

On the other hand, according to the Interamerican Development Bank (IADB) crude oil production is growing faster in Latin

1980

it stated

America shan in any other region of the world?, In i

report on economic and social progress in Latin Americ:

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thet oil production in Latin America expanded by nearly 10 per cent and the region's share of the world oif markedly rose from

percent in 1077 to 9.8 percent in 1980. At year end, the total oil output of the region reached to 2.123 billion barrels, exceeding consumption by sbout 700 million barrels an increase of 100 million barrels ver 1979. The rate of growth in production

was the highest since 1973, and compares favorably with the 8.5

percent expansion of 1979. Combined production of Mexico and

Venezuela accounted jor nearly 75 percent of the region's crude

el! production from 1975 16 1980, although Venezuela's share fell irom 53 percent in 1Y73 to 37 percent in 1980, while Mexico's productiсn rose from J percent of the region's output to 37 per cent during the same period. Concerning oll exportation, "the

single most iportant event during the past five yeare has been Menico's contribution to the region's increased sales of crude to

external markets," the IADB report said. Mexican of reports in-

creases of 116 percent in 1977, 79 percent in 1978, 47 percent in 1974 and 55 percent in 1980 when they totaled about 303 million barrel. Production also expanded in Argentina, Brasil, Chile, Peru and Guatemala, but it declined in Bolivia, and Trinidad and Tobago. In Venezuela, production declined by almost & percent as a result of conservation messures enforced by the Govern ment?,

?The Mexican and Venezuela governments are implementing an important oi! purchasing financing agreement for the Caribbean, The New York Times editorialized recently that the Caribbean is

being rediscovered again®. The agreement covers up to 80,000

barrels for ©

A country, According to the agreement, a eum equi-
valent 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 i

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.

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The World Bank fas also called for an international research program to improve and broaden the use of renewable energy technologies in developing counties?. 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 report concludes

that "present research efforts to improve biomass production are

energy consumption cumes irom >iomass,

inadequate to begin to resitte the enormous potential of this resource for the longer term. A well designed and executed biomass rescarch 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 shoulé 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 de veloped countries (LDCs) to assess and adapt new technologies for their own national programs. The aim of such an internation- al program would be to develop reliable data on renewable energy

in different coun-

technology performance, evaluate experience:

tries with the adoption of the te

jologies, and make global
assessments of future technological developments and their im plications for developing countries.

?The Latin Americs Plan for Action for the United Nations Con

ence on New and Renewable Sources of Energy recommended

that priority be given to the following:®

1, Regionsl Basie Support

a. energy planning

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bs information and dissemination

training

2, Integral Regional Development

a, hydroelectric

bs firewooe and charcoal

?- liguid fue! production

@. solar energy

fe. vegetable residues

f. geothermal energy

8. biogas

h. wind power

he Caribbean Region

the Caribbean region the crude petroleum and refined pro

duets share of total merchandise smports increased from less than

9 percent in 1971 tw about 25 percent in 1980. Petroleum imports

to the Region increased during 1972-77 from $150 million to $620

nillion 1m 1980, since all Caribbeun countries with the exception of

Trinidad and Tobago are net importers of energy.

The Caribbean nations share several energy characteristics:

1) the suberitical size of most national energy systems

precludes 4 choice of solutions;

8

3) indigencous fuels have not been able to replace the use

2) there are no

ed markets for indigeneous fuelsy

of imported petroleum;

4) commercially exploitable indigencous resources are

Limite

5) there is @ shortage of trained personnel to carry out energy assessments and develop alternative energy programs:

») 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 fom less than ten megawa

fs to several hundred

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megawatts (See Table 1). The commercial sector demands for electric energy in the smaller ielands 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.

?Yo solve the energy probiems in the Caribbean Regions we must first recognize that there are a large amounts of natural energy in the area which are not utilized. This situation arises from our own common geographical and ecological circumstances.

?The potenti

by the Region, and some countries are exploring the possibilities

for renewable energy is only now being recognized

for nonconventional sources through research and demonstration.

A conmultant for the United Nations Development Programme (ONDP) concluded recently that hyéro, geothermal, solar and charcoal slternatives should be developed with priority in the Caribbean. This recommendation generally agrees with the report Energy Resources in the CDCC nember 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) Ma

2) Cooperat

cation of energy accounting systems which may be

.gement will involve:

jon and technical assistance in the appli-

used as the basis for the formulation and imple-
mentation of sound astional energy policies and
programmes.

b) Reinforcement of regional and subregional inte-

ith the

grated non-conventional energy activities

cbjective of # fuller exchange and dissemination of
all available information and provision of training

opportunities.

?) Development of a cooperative programme for the

implementation of appropriate technologies and

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practices for waste disposal with special attention
to reeyelying, energy generation and the special
problems of the smaller islands.

?The sources that are considered in this paper? are geother-
mai, solar, ocean thermal energy conversion, hydropower, biomass,
biuconversion and wind.

1k is important to mention that the United States Agency for
International Development (USAID), with the Caribbean Develop
ment Bank (CDB) and CARICOM, as implementing agencies, is

financing since 1979 $7.6 million grant for energy development, including energy planning, assessments, design, testing and dissemination of alternative energy technologies. Based on the achievements of this exercise, feasibility studies will be pre~

pared in support of further financial assistance from regional, multilatersl, bilateral and extraregional sources. USAID is in the process of formulating additional assistance projects totalling

about $20 million for similar activities in the Dominican Republic,

Guyana snd Jamaica and for a follow-on project for the Caribbean regions as a whole. Already a USAID lean of $7.5 million has been approved to help Jamsica establish an energy program!?, Program's goal is to. strengthen the island nation's ability to de-

velop and carry out energy projects, expand energy conservation

programe and Gevelop alternative energy sources.

jothermal Power

The whole Caribbean Region is part of the Caribbean Tectonic Plate which occupies most of the Venezuela and the Colombia basins and moves east relative to both the North America Plate on Mts 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 balsaltic 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

result ir continuous readjustments of the crust!)

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Figure?

PLATE BOUNDARIES OF THE CARIBBEAN REGION

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Regions of geothermal reservoirs are generally located along the margins of major crustal or tectonic plates; the Lesser Antilles is recognized ss one of these zones. A tremendous waste of energy in these areas comes from volcanic eruptions, with large amounts of hot (700°C te 130°C) magna from the mantle being expelled through the crust (See figure 3).

Val

fos exist in the Lessur Antilles. Martinique has the

presently inactive Mont Pelee. in Guadaloupe @ vein

steam con

necting with La Soufiriere volcano has been tapped by drilling at Bouviliance off the west coast. This drilling has been capped

and, because the pressure is sufficient to operate a geothermal

electricity generating station,the necessary plant and equipment has been ordered. Reports of potential geothermal energy resources in Dominica, Montserrat, Si. Lucia, St. Vieent, Dominican Re

public, Grenada, Haiti and Jamaica have been published. St. Lucia ls already planning to develop its thermal source of power at

Soufiriere with 1 to 5 megawatt units. In 1969, a United Nations study was Gone in Dominica where the extensive surface manifesta~ tions meke the geothermal potential quite apparent. In regard to Maiti and Grenada it will be necessary to determine the origin of the hot springs to learn whether they are geochemical or geother= mal before

ny exploratory drilling can be attempted. A feastbil ity study of geothermal is currently underway for generation of electricity in the Dominican Republic.

Geothermal energy has some environmental disadvantages be- cause gases such a6 carbon ionoxide and traces of hydrogen sulphide are capable of polluting the stmosphere. However, this problem can be minimized with the appropriate expertise and re~ sources. It is 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 Calitormia, New Zealand, Mexico and Central America.

Solar Energy

Solar Energy as an alternative source of energy hes received

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the greatest attention in recent times. Essentially all our energy, except nuclear and geothermal, is derived directly or indirectly irom the sun. The solar radiation in the Caribbean Region is of the order of two thousand kilowatr hours per square meter per year. Average air temperature varies from about 78°F in February

to 83°F in September. Nearly fi:teen times more solar radiation

reaches the carth's surtaces than the total consumption of com= mercial energy. Presently, solar energy is used on a very limited scale in the Caribbean for crop drying, water purification, heat ang and distillation. Two solar atilis have been built by a foreign research institutes, one in Haiti and one on St.

Vincent in the

castern Caribbean. These stills have been successfully providing potable water to smal

ure] communities. Solar crop-dryers have
been built in Grenacs for drying nutmegsyin Guyana for chill
peppers. ang in Barbados for sugarcane. The application of

solar energy for water heat!

ing has reached satisfactory levels of
development im Jamaice, Barbados and Puerto Rico. By the latest count, there are more than 15,000 solar water heaters in Puerto Rico in residential use. The development of solar industrial steam generators and solar air conditioned units is being pursued by the Center for Energy and Environment Research (CER) of the Urnversity of Puerto Rico. A 1,100 square meters solar air cone dinones tactory in Canovanas, Puerto Rico, and a new 400 square meters solar air conditioned Post Office in Guayama, Puerto Rico are examples of commercial installations.

In Barbados passive solar designs have been used. An example 1s the Technical Energy Unit (TEU) building of the Caribbean Development Bank (CDB). Testing of this passive system is in progress. Also a solar air conditioning system has been ins-

talled and 16 being tected in the new Barbados Government Analyst Laboratory. USAID and the Latin American Organization for Energy Development (OLADE) are financing the design and fabrication of

@ sclar system in Haiti at 2 total cost of $9.5 million,

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Ocean Therma! Energy Conversion (OTEC)

Strong ocean surface currents pass through the Caribbean Sea from the Atlantic and continue with inereasing speed through the Yucatan channel, The main current flows at an average velo~ city of about one mile per hour. Also, temperature gradients between the ocean surfaces and 1900 meter depths are more than

22°C (40°F). Great sources of untapped energy exist in these

currents and temperature gradients. The maximum depth of the

Caribbean Sea is 6,15 meters about 160 kilometer south of Puerte

Rico in the Muertos Trough. However, depths of 1000 meters are encountered two kilometers southeast of Puerto Kico. Consequent= ly the CEER is actively working on the development of an OTEC Project on the southeast coast of Puerto Rico!!. Jamaica is plan~ bing an OTEC demonstration project, and the government of Holland has proposed 3 demonstration project for Curacao where Gepth of 5,000 meters can be reached only 1,500 meters offshore. Gusdaloupe and St, Croix have mace preliminary evaluations of their OTEC potential and Barbados of its wave energy potential on ite east const.

Hydropower

ican Re-

Hydropower is important in Dominiea, Haiti and Dor public. Hydropower supplies 90 percent of power generation in Dominica and 27 percent in the Dominican Republic. It could also play an important rele in Guyana, Surinam and Jamaica. In

Guyana, hydro potenual of from 7,200 to 7,600 megawatts has been identified, and in Surinam a hydropower potential of 3000 megawatts exists, Belize is interested in mini hydro projects. A Colombia engineering firm is providing technical assistance to Haits ane Dominica in order to develop small-seale hydroelectric resources!®, E] Centro Ia Gaviots in Colombia has develop some

mn: hydro technologies suitable for the region.

Sugercane Is growing in many of the Caribbean countries

and a large quantities in Barbados, Cuba, Dominican Republic,

a12-

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Guyana, Haiti,

Trinidad and Tobago. Sugar factories in Haiti are able to satisfy all their energy requirements from bagasse and in Barbados 90

Jamaica, Puerto Rico, St. Kitts-Nevis, Anguila,

percent of their energy requirements. Considerable use is made of bagasse as fuel for sugarmilis in Guyana, Puerto Rico, Jamaica and other countries, Firewood, charcoal and bagasse provide an

estimated §0 percent of all primary energy supplies in Haiti

?The energy content of dry bagasse is about 5.15 kilowatt

> $1.60 mil=

hour per kilogram. An extensive program of more th:
on for the development of bagasse and tropical grasses for energy use has being going on for four years at the CEER in cooperation with the Agricultural Experimental Station. In this program the alternative use of sugarcane to produce both bagasse and the manwiacturing of molasses and alcohol has been pursued: also the optimization of tropical grasses for biomass production hhas been studied.

Bigconversion

Bioges is produced when organic wastes, manure, vegetable matter or human waste are decomposed by bacterial action in anae~ robic conditions such as those found in an airtight digester. The biogas produced has composition of approximately 55 to 65 per- cent methane (CH,), 35 to 45 percent carbon dioxide (CO,), and

traces of oxigen, nitrogen and hydrogen sulphide. It is combus- uble with a eslorifie value of 20,000 to 25,000 kilo joules per cubic meter, and it can be used for cooking, heating and refrige- ration. Once the gas production has ceased in the digester, the residue forms an excellent fertilizer which can be used to grow algue. and the liquid can be extracted for irrigation.

® 1,000 pig farm is being operated successfully by private enterprise 1m the south of Puerto Rico. All of the electricity at the farm comes from local biogas production, and also algae is

grown as 2 feed supplement for the pigs. For example it has

becn estimated than the manure from one large dairy cow could

yiela 2.5 cubic meters of biogas per day, roughly equivalent to

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one-third of @ gallon of gasoline. It has been estimated that waste from one thousand poultry broilers will be capable of producing about 10 cubic meters of methane per day, energy ?equivalent to one hundred kilowatt hours per day. If one assumes 30 millions broilers, the energy potential equivalent to the

methane produced wall 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 cemonstration unit. Barbados has set up three biogas digestors in their Island. Puerte Rico:

now designing one large

unit to use animal wastes, and the Bacardi Corporation has ins~ talled 2 3.5 million gallons anaerobic digester tank to treat their

distilleries residue wastes before dumping to the ocean.

The disposal of municipal wastes becames a more serious pro~
blem every year because of the continued urbanization of the
Caribbean countries. It may be possible for municipal waste to
make @ substantial contribution te solve both the energy and waste
problems by converting the latter to 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 present

land disposal si
Winds

Wind energy is the main subject of this seminar, and conse
quently some aspects of it will be discussed more extensively.

The northeast trade winds prevail over the Caribbean cea.
?The winds blow consistently from the east or northeast more than
TO percent vi the time at means velocities of about 10 miles per
hour. Because of this favorable condition, 2 200 kilowatt wind
power generator was installed by the L.S. Department of Energy

(DOE) on the ssland of Culebrs in Puerto Rico. This energy machine is being evaluated at present

Several of the Caribbean Islan

is show great suitability for the utib-otion of wind energy. The Caribhean has had long ex-

perience in usirg wind as @ source of energy. Boats have been

oe

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powered by wind for many years. Prior to the introduction of machinery for crushing sugarcane, small factories were situated fon clevated 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 Rockfeller 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 wing speeds in the Caribbean Region.

A wind turbine generator factory has been installed in Puerto

Rico by the Future Energy RuD Corporation.

Because of ite importance, some comments about the environ=

mental effects of windmills are significant. The impact of wind

turbines on the environment can be generally classified in four

A brief discussion of each of these topics follos:

1) Noise effect

The noise produced by large wind turbine

generators is the most objectionable environmental

effect. The 2000KW wind turbine generator devel-

oped by the U

as the MOD=1 model was operated for the firet time

at Boone, North Carolina, in 1980.

Department of Energy and known

During the operation of the machine there was at

certain periods (1 percent of the time) 2 sound amplification

or focusing problem raising the noise level to values of up

to 77 decibels. This is equivalent to twice the noise level experimented at a busy metropolitan intersection!®, Some people allegediy 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 Z3rpm by moditying the gear yeduction box. This spparently has solved the pro-lem.

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It should be kept in mind that wind turbines are lo-cated in quiet country surroundings and that a little noise

may be considered nuisance to local residents, Efforts

must therefore be made to define standards of acceptable

noise levels for these environments and then to develop

adecuate computer programs to predict the noise level of

planned wind turbine generators.

2) Radiointerference effects

The rotation of wind turbine blades generate radio-frequency noise which may interfere with TV reception. ?The MOD-1 machine just mentioned 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 mach with television reception that the island was wired for cable television'?, There are various solutions to this problem depending upon the local situation. These solutions include:

a) The use of Cable TV; cable TV, however, is only

econoinical in high population density area

b) The use of translators for changing from VHF to UHF. This is very good for sparsely populated

¢) The use of high performance antennas. These antennas will pick up a stronger signal from the transmitting TV station. The ratio of signal to

noise is larger and the electronic can work proper-

ly. The cost of the antenna, however, is high.

3) Air disturbance and reduction of wind power in nearby

private properties.

Wind flow pattern is altered by the presence of a wind

turbine machine. At optinan operating condition of the

turbine the effect might be felt as far as 15 diameters of

Hib.

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the machine rotor. 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 300ft. diameter rotor machine like the MOD-1

2000KW machine, the effect will be felt for a distance of

4800ft. This could affect the neighbor's wind turbine.

4) Aesthetic effects

Wind turbines ean present an objectionable sight when
located nearby sophisticated residential areas. For example,
the mayor of Desert Hot Springs in California has objected to

South California Edison's Plan to build a forest of wind

machines there claiming "It will create a visual blight and

it hae the possibility of destroying our Tourism base."!?

All environmental impacts of wind turbine appear to be insig~
nificant when compared with other energy sources. Consequently,
more than 100 United States electric utilit
projects!?, Southern California Edison is already testing wind
machines in the San Gorgonio Pass and it has signed agreements
to purchase as much as 85 megawatts from 50 wind turbines. await
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 t Electric Co, to buy as much as 350 mega

es are considering wind

watts of wind power!*. Also three 2.5 megawatt wind turbines (MOD-2) are operating at Goodnoe Hille, Washington for the

Bonneville Power Administration!°, The turbine's blades are each

300 feet long; the towers are 200 feet tall; and the blades rotate at 17.5rpm. MAN in Germany is engineering and constructing a Growin (grosse wind cnergian lage) 3 megawatt wind energy machine!®

Wind sppears as one of the most promising energy alterna~ tives for the Caribbean Region. Coastal winds could be of signif

lcance for meeting local energy devands and thereby reducing

?7.

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investment requirements for transmission and transport of elec tricity and fuels,

CONCLUSIONS

This paper briefly discussed the renewable energy technolo~ gies, 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 inepired by the concept of ecosystem, and capable of jointly supplying human necessities. Environmental appears in this perspective as a resource potential to be harnes- sed on a sustainable basis and, as much as possible, in an ecolo~ gically benign manner, We are thus recommending the eco develop- ment approach for renewable energy technologies utilization including wind power !7

Caribbean renewable energies development and potentials are

nt that these renewable ener~

summarized in Table 2. It is importa

gies be examined in the light of four basic forms of energy use, namely: liquid transport fuels, centralized electric power,

Gecentralized 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 encrgies in the Caribbean Region. More details of some of these projects are given in 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

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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 istillation, 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-size windmills used in 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 ts important to determine its wind potential and how soon will it become economically competitive.

Other new and renewable energy technologies such as the ?ocean thermal energy conversion, geothermal energy, large-scale solar ponds, tar sands and oil shales are all very promising. With suitable support for researeh, 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 uti-

zing existing institutions in the Caribbean.

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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 ¢e Ciencia y Tecnologfa

México

Departnent of Energy (U.S.)

European Development Fund

European Investment Bank

International Bank for Reconstruction ané

Development (World Bank)

Inter-American Develozment Bank

National Air Snace Administration (U.S.]

Organization of Anerican States

Latin American Organization for Energy

Developrent

Puerto Rico Electric Power Authority

Technical Eneray Unit

Interin-Fund ~ United Nations Interin-Fund

United Nations Oevelopnent Prograrme

Caribbean Universities and Research

Institutes Assoctation

United Nations International Children's

Emergency Fund

United States Agency for International

Developrent

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