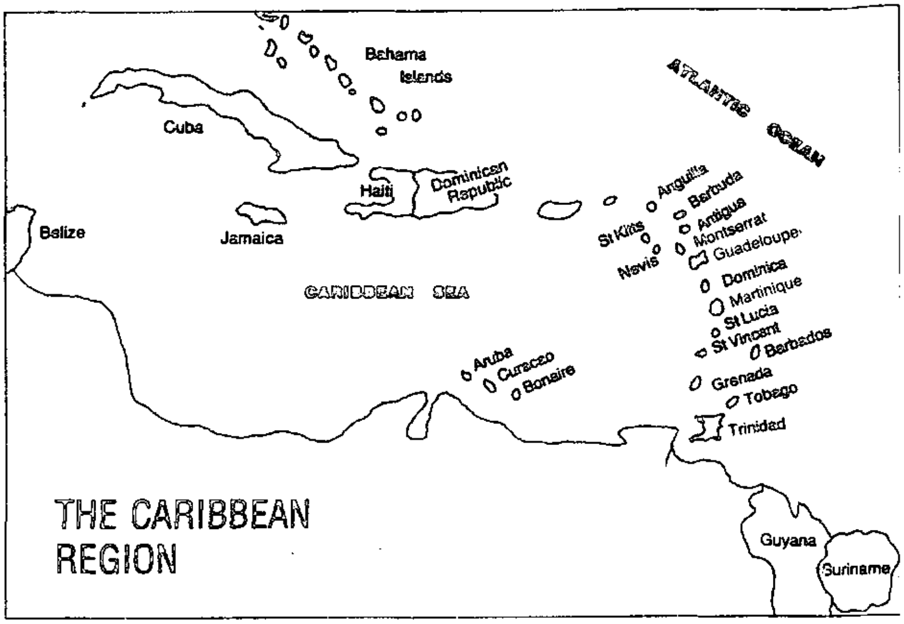
CARIBBEAN DEVELOPMENT AND CO-OPERATION COMMITTEE



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ENERGY RESOURCES IN THE CDCC MEMBER COUNTRIES

UNITED NATIONS
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P R E F A C E

This paper is essentially a revision and expansion of the document titled "Preliminary Draft Paper on Energy Resources in the CDCC Member Countries (CEPAL/CARIB 79/3)" which was among the background documents available at the CDCC Fourth Session in 1979.

Since last July visits have been made to some countries and additional data have been collected. It is still correct to say however that most countries have not provided the range of information requested on the questionnaires that were sent out in the latter part of 1978. This lack of data is responsible for many of the blank spaces in the appendix to the paper.

References are listed at the end of the text and are indicated by numbers which punctuate the text. This step has been necessary because of the large number of sources that had to be consulted directly in the search for facts.

* * * * *

Explanatory Notes

1. Definitions of symbols used in tables:

-	None, in negligible quantity or entry not applicable.
...	Data not available.
P	Preliminary.
E	CEPAL's Office for the Caribbean estimate
MT	Metric Tons
gall/min	gallons per minute
L/min	litres per minute
kg(s)	kilogram(s)
m^3/s	$metres^3$ per second
km	kilometre
km/h	kilometre per hour
MW	Megawatt
kW	kilowatt
kWh	kilowatt hours
kJ/m^3	kilojoule per $metre^3$
b.p.d.	barrels per day
kcal	kilocalorie
Tcal	teracalorie
mill	million
^oC	degree Centigrade or Celsius
*	US dollars used throughout

2. Abbreviations

CDCC	Caribbean Development and Cooperation Committee
OAS	Organization of American States
UN	United Nations
UNDP	United Nations Development Programme
UNIDO	United Nations Industrial Development Organization
USAID	United States Agency for International Development
FAO	United Nations Food and Agricultural Organization

INTRODUCTION

As primary producers of agricultural commodities, the CDCC countries have to rely heavily on imports to satisfy most of their basic needs. One of the areas in which this fact is clearly evidenced is in the field of energy. Energy demand had been met mainly by relatively cheap petroleum imports but also with fuelwood, charcoal and natural gas in very few countries. However, since the Organization of Petroleum Exporting Countries (OPEC) raised crude oil prices drastically, the once cheap source of primary energy in now quite expensive, resulting in severe balance of payments problems for the non-producers. This occurence has brought to the forefront the gross dependence of CDCC countries on liquid petroleum and consequently the urgency of utilizing alternative sources of energy.

As a first step, a concerted effort ought to be made to take a comprehensive inventory of all energy resources in the CDCC area. The next step in an energy programme would involve detailed research and investigation of the potential including indications of feasibility and necessary follow-up actions. Following this, policies to determine priorities in an integrated development programme ought to be established. In this connection, it may be pointed out that in the development of non-conventional energy resources, possibilities exist for small-scale, labour-intensive and rural installations which could facilitate development in other sectors. Development of non-conventional energy resources could therefore be linked for example, with the various attempts made to reverse the urban drift, to alleviate unemployment and to boost agriculture.

It is hoped that this preliminary draft will give some insight into what exists and can probably be utilized, especially in the non-conventional area. Further mention must be made of the veritable dearth of quantitative data. Not enough resources, both human and economic, are directed towards this extremely important aspect of development.

For the purpose of this paper, energy resources will be classified as conventional and non-conventional. Conventional energy resources refer to those traditional sources of energy - petroleum, natural gas and hydro-power, plus thermal electricity and petroleum refining facilities. Included also are charcoal and fuelwood, major traditional sources of energy in rural areas. Under the term non-conventional energy resources are some promising alternatives including geothermal, solar, nuclear and biomass.

The geographical area under consideration refers to those countries of the Caribbean region that have membership status on the Caribbean Development and Co-operation Committee (CDCC), namely the Bahamas, Barbados, Belize, Cuba, the Dominican Republic, Grenada, Guyana, Haiti, Jamaica, Trinidad and Tobago and Dominica, St. Lucia and St. Vincent as well as the Associated States of Antigua, Montserrat and St. Kitts-Nevis.

CONVENTIONAL ENERGY RESOURCES

Petroleum

At present, all CDCC countries, with the exception of Trinidad and Tobago, are net importers of energy, mainly in the form of petroleum. Only four of these countries, namely Barbados, Cuba, Dominican Republic and Trinidad and Tobago, extract crude petroleum commercially. A few other islands have discovered oil "shows" and other favourable signs of possible existence of petroleum.

Conservative estimates of petroleum reserves are as follows:

Barbados	-	(No definitive information, probably 2×10^6 barrels)
Cuba	-	Not known.
Dominican Republic	-	Not known..
Trinidad and Tobago	-	1.2 billion barrels.

Crude oil reserves, as the reserves of natural gas are dependent upon the amount of exploratory work that has been done to establish those reserves. Trinidad and Tobago at the end of 1978 estimated their reserves at 1.2 billion barrels[18/]. If the level of production of 229,527 barrels per day (b.p.d.) at the end of 1978 is maintained, they would be extracting some 80 million barrels of oil per year and if there is no change in extraction rates, the reserves identified should last approximately fifteen years.

There are no firm estimates of the reserves of crude oil in Barbados. In 1974 it was conservatively estimated[15/] that between then and 1981 some 60,000 barrels of crude oil could be recovered from each well and that the ratio of gas to oil was approximately 28.3 cubic metres of gas per barrel of oil. It was calculated that 1 million barrels of oil and 28.3 million cubic metres of natural gas could be expected to be recovered during this period. However, a new drilling programme started in 1977 resulted in increased extraction rates of about 900 barrels per day - approximately one third of the present volume of crude utilized.

Cuba's oil fields produce about 3 percent of their 200,000 barrels of fuel that are consumed daily.

Cognizant of the need to be less dependent on imported crude oil several countries have embarked on hydrocarbon exploration activities, both on land and off-shore.

Two oil companies have been granted licences for oil and gas exploration in a large area of Guyana's off-shore waters.

In Belize, an oil vein some 60 miles wide has been discovered stretching across the continental shelf and inland Belize. To date, 35 wells have been drilled off-shore and one well on-shore, near Belmopan, which yielded a flow of 60 bbls per day. However, due to low rock porosity this flow cannot be sustained. A large area off-shore Belize, has not yet been leased out, as water depths (300 - 600 fathoms) are beyond present technology[11/].

In the Dominican Republic, five basins with geology conducive to hydrocarbon formation have been sited. The Government has granted hydrocarbon exploration and exploitation rights to several companies. There is some minor production from oil wells and recent shows of natural gas. However, commercial possibilities have not yet been established. Altogether some 20 exploratory wells have been drilled to date.

Tests are being carried out off-shore in the Pedro Banks area off Jamaica's coastline, an area which is reported as having the greatest potential for an oil-find. Seven wells were drilled during 1977, six off-shore which were dry and one on-shore which had a gas "show". Seismic and geophysical studies are still in progress[11/] and cover an area of 3,900 square kilometres.

In Cuba, recent exploration efforts so far seem to have failed to yield any significant discoveries.

Exploratory drilling and geophysical surveys undertaken during 1974-1976 in the Port-au-Prince Basin in Haiti show potential hydrocarbon geological structures.

No hydrocarbon exploration has been undertaken in Dominica, Montserrat, St. Kitts, St. Lucia and St. Vincent so far as is known.

In Trinidad and Tobago one jointly owned (government/private foreign) company plans to initiate further seismic analysis, off the south-eastern coast of Trinidad, and further exploratory drilling on land, in an attempt to find new oil discoveries.

Although the region can satisfy only a small portion of its crude petroleum needs, it nevertheless produces a substantial amount of petroleum-based products. There is a total of 11 refineries in the CDCC region, with capacities ranging from 150,000 to 26.8 million metric tons per year.

Barbados has a 3,000 barrels per day (b.p.d.) refinery owned and operated by a trans-national Corporation which produces almost all the country's needs.

Jamaica has a 33,000 b.p.d. refinery, also owned and operated by a trans-national corporation, which meets domestic requirements for most petroleum products with the exception of aviation fuels.

Cuba with 3 refineries and total refinery capacity estimated at 133,970 barrels per day,[17/] produces significant quantities of naphtha, a refined product which serves as a feedstock for petrochemicals. The Cuban Petroleum Institute operates the 4,970 b.p.d. Cabaiguan refinery; the Santiago de Cuba refinery has a capacity of 54,000 b.p.d. while the Havana refinery registers 75,000 b.p.d. As of early 1979, a new refinery was under construction. Approximately 95 to 97 percent of crude petroleum inputs were imported in recent years.

A large multi-national company has received concessions to construct a 250,000 b.p.d. refinery in St. Lucia, valued at an estimated $50 million. Presently the oil trans-shipment terminal's first phase of the project is operational.

The Grand Bahama refinery in the Bahamas, also foreign owned, has an operational capacity of 500,000 b.p.d. Like St. Lucia, the Bahamas also have a recently built crude oil transhipment terminal, about 30 miles east of the Free Port harbour.

The Antigua Government intends to re-open a refinery which was closed down in 1975, because of high production costs and lack of markets and in the aftermath of an earthquake which damaged plant and storage facilities. While the refinery is small by international standards their 18,000 b.p.d. capacity far exceeds domestic demand and potential bunker sales. Availability of export markets figure prominently in any decision to resume refinery operations.

The Dominican Republic produces small non-commercial quantities of crude oil but their 33,000 barrels per day refinery jointly owned by the Government and a trans-national corporation, meets domestic requirements for all petroleum products, with the exception of diesel and fuel oil, which have to be partially imported.

The main products of these refineries are motor gasolene, kerosene, jet fuel, fuel oils, lubricating oils and greases. Table 1 below shows production and trade patterns of energy petroleum products over a recent three year period for some CDCC member countries.

In any assessment of the natural resources of a country, the issue of ownership is of paramount importance since country and corporate interests are frequently at variance. Petroleum in the Caribbean fits into the typical pattern of control by foreign multinational corporations. To date, with the exception of Cuba, no CDCC country has autonomous control over this sector of its economy. In Trinidad for example, of the petroleum companies operating on the island, one is state-owned and two are jointly owned by the Government and transnationals; the others being subsidiaries of transnationals. In the Dominican Republic and the Bahamas, a similar situation occurs. The Cuban experience is different, in that the three refineries there are state-owned.

Generally countries charge royalties, collect excise taxes, income and other taxes from companies in this field, but in some cases special concessions have been granted to the companies. In an effort to obtain a greater share of the earnings generated in the petroleum industry, tax rates are usually increased. The income tax applicable to the oil industry in Trinidad was drastically altered with the introduction of the Petroleum Act 1974. This act provided for the separation of the operations into crude oil production, refining and marketing for tax purposes, and revised the method of fixing of tax reference prices and the refinery throughout tax.

TABLE I

PRODUCTION, CONSUMPTION AND TRADE OF ENERGY PETROLEUM PRODUCTS
(Quantities in Million Metric Tons)

	Antigua	Bahamas	Barbados	Cuba	Dominican Republic	Jamaica	Trinidad and Tobago
Production							
1974	0.285	9.691	0.133	5.105	0.877	1.587	18.129
1977	...	7.634	0.157	5.716	1.189	0.972	13.658
1978	...	7.715	0.169	5.721	1.223	1.032	13.105
Consumption							
1974	0.077	0.860	0.142	6.898	1.965	2.408	1.654
1977	0.046	1.050	0.150	7.612	1.428	2.410	1.487
1978	0.064	1.092	0.170	7.631	1.545	2.525	1.522
Exports							
1974	0.133	10.543	0.012	...	...	0.57	15.188
1977	...	6.840	...	...	...	0.029	11.311
1978	...	6.860	...	...	...	0.040	10.698
Imports							
1974	0.103	1.400	0.257	1.793	1.090	1.110	0.097
1977	0.121	0.862	0.169	1.896	0.240	1.606	0.059
1978	0.143	0.848	0.165	1.910	0.323	1.689	0.065

Source: See No. 10 of List of References

Natural Gas

Natural gas is a combustible gas that occurs in porous rock of the earth's crust and is found with or near accumulations of crude oil. Natural gas may be found alone but more commonly it is found as a cap of gas in a reservoir trapped between liquid petroleum and a layer of impervious rock. Where the pressure is great, natural gas may become mixed with the crude oil. Its main use is as a fuel but it is also used in repressuring wells as well as to produce liquid natural gas, natural gasoline and certain chemicals.

Natural gas is present in a variety of rock systems, therefore additional discoveries in the energy scarce CDCC area are not ruled out despite the general association of natural gas with crude petroleum. Natural gas is currently extracted commercially in Barbados, Cuba and Trinidad and Tobago.

The largest known reserves are to be found in Trinidad and Tobago. In 1978 proven reserves were 6.06 billion cubic feet, probable reserves 4.16 trillion cubic feet and possible reserves 1.82 trillion cubic feet, totalling 12.04 trillion cubic feet. With a little more exploratory work, it is estimated that a total of 21 trillion cubic feet could be identified altogether. The total gas requirement for Trinidad and Tobago to the year 2017 has been put at 8.6 billion cubic feet, thereby leaving a surplus of some 4 billion cubic feet over the conservative estimate. For Barbados at the end of 1976, current reserves were estimated at 933 million cubic feet though this figure is considered an underestimate. Information on the reserve position of Cuba is unavailable.

In view of the existence of geological formations deemed favourable for the presence of hydrocarbons and indeed the existence of crude oil in the Dominican Republic and possibly also in Suriname and elsewhere, there is the distinct possibility that the actual reserves of natural gas in the CDCC area will be much higher than indicated above.

In order of importance, the producers in the region are Trinidad and Tobago, Cuba and Barbados, as the following table indicates. In Barbados, utilization of natural gas represents about 3 percent of total annual utilization of commercial energy; the figure for Trinidad and Tobago exceeds 55 percent currently, while the share in Cuba's consumption is negligible.

TABLE 2

Natural Gas Production

('000 teracalories)

Years	Trinidad and Tobago	Cuba	Barbados
1973	16.874	0.135	0.028
1974	15.434	0.182	0.018
1975	14.084	0.158	0.020
1976	15.7 4	0.196	0.039
1977	18.822	0.200	0.039
1978	22.880[e]	0.220[e]	0.070[e]

Source: See 10 of List of References

Natural gas is utilized for household and commercial purposes in Barbados. Sales to commercial firms have increased rapidly and accounted for more than 53 percent of total sales in 1979. In Trinidad and Tobago, however, the problem is to make full use of this valuable resource. Presently, natural gas is used in areas such as electricity generation, in petroleum refining and in the petro-chemical industries. During 1977 natural gas consumption by households accounted for more than 8.5 percent of their total consumption of primary energy.

Approximately 65% of the gas found in association with crude petroleum in Barbados is delivered to the Natural Gas Corporation, a public utility reporting to government; a small portion (10 - 15%) is used in pre-refining processes carried out in the oil field, and the rest which is equivalent to one-tenth of the amount of imported gas for the year 1977 was flared. As exploration continues, and extraction rates increase it may become quite feasible to establish a plant for the liquefaction and bottling of domestically produced gas in Barbados.

This problem of the flaring of natural gas, is not confined to Barbados. It is a problem which oil-producing countries face, especially where the gas is associated with the production of crude oil. Gas flared was 36.5% of the total production for 1977 in Trinidad and Tobago. (Compared with around 2 percent flared in the U.S.) Consequently the government of that country has plans to establish a compressing station off-shore at Teak Field, to send some 15 million cubic feet of gas per day on shore.

In Trinidad and Tobago most of the producers are foreign multinationals operating under agreement with the government. One such agreement ensures the provision of gas to the sole electric utility. Previously natural gas was sold directly by the producers to the utilizing firms. Recently a Natural Gas Corporation has been established. Part of its function is to purchase natural gas from the producers and transmit to the users. Focal point in Trinidad and Tobago for hydrocarbons is the Ministry of Energy and Energy Based Industries.

COAL

Coal deposits are known to exist in some CDCC countries, some of which have been exploited on a very limited scale in the past. Available data are given in Table III of the Appendix. Low grade coal deposits (lignite), have been found in Jamaica, in the St. James, St. Elizabeth, and Trelawny areas. However, the extent of these deposits has not yet been assessed. Indications of peat deposits in the "Lower Morass" area of St. Elizabeth suggest that they are not of commercial significance.

In Haiti, especially in Maissade in the Plateau Central, and Camp Perrin, there are extensive deposits of lignite, whose extent and quality need to be assessed. In the Central and Southern parts of Trinidad, lignite deposits have been discovered; however as is the case of Jamaica and Haiti, systematic studies are necessary in order to establish the potential and feasibility of exploitation of these resources.

It is of interest to note that as recently as 1978 Cuba, the Dominican Republic, Jamaica, Suriname and Trinidad and Tobago imported solid fuels (coal and coal products). There were imports into the Bahamas up to 1975. Cuba's imports were the largest, around 135 thousand metric tons in that year, but the quantities were very small for the other countries.

Hydro-power

Hydro-power is the oldest known mechanical power source, and has various properties which make it very suitable for use in non-oil producing developing countries. It is low in cost, high in efficiency, and is least polluting of the conventional energy types. Additionally, it has the capacity to be easily adapted to non-power uses such as flood control, irrigation, water-supply etc.

Implementation of this energy resource is limited by the topography of many of the CDCC countries, since some of them are relatively small with a few small rivers or none at all and suffer low rainfall in some cases. These islands include the Bahamas, Antigua, Barbados and St. Kitts.

At present hydro-power is of relatively greatest importance in Dominica, Haiti, Dominican Republic and Suriname, and is utilized to a lesser extent in Cuba, Jamaica and St. Vincent.

Up to 1976 installed hydro-electric power capacity in the region totalled approximately 390,000 kilowatts, of which Suriname accounted for over 47% and St. Vincent less than one percent. Generation varied from 10 million to 1,176 million kilowatt hours (kWh).

The steep rise in petroleum prices since 1973 induced countries to give consideration to the further utilization of hydro-power. Haiti, for example has increased hydro-power capacity by 50 percent between 1972 and 1974 but since that time there have been no additions. In 1978 hydro-power provided an estimated 80 percent of total electricity generated. Potential capacity has been estimated at over 145 MW but up to 1978 only 47 MW had been installed. The possibility of developing another 60 MW of capacity is being investigated for Haiti.

Hydropower is Dominica's major source of commercial energy. Hydro-schemes of 2.8 MW, account for 34 percent of the installed capacity and nearly 90 percent of power generation. Despite the apparent potential, development is not without problems. Dominica is a small island and too many of the rivers have small catchment areas and flow steeply to the coast, offering little scope for appreciable storage, and necessitating the construction of dams. It is estimated that Dominica's hydro capacity can meet electricity requirements throughout the 1980's.

In Belize, hydropower potential is believed to exist on the Rivers Macal and On; some studies have been done on the installation of small-scale (less than 1 MW) hydroplants, as well as larger projects. Unfortunately, possibilities seem to be limited by the substantial engineering requirements and high costs involved in hydropower development in Belize. Additional studies were to be conducted in 1980.

Hydropower appears most promising in Guyana and Suriname. Hydropotential totalling nearly 7600 MW has been identified in Guyana's eight major river systems. About half of this identified potential is located in the Mazaruni River Basin, where the government has plans to develop over 1,000 MW of capacity to provide for future development including a 200,000 tons per year aluminium smelter.

Present capacity (1978) in Suriname is about 200 MW but potential capacity exceeds 3,000 MW. About 85 percent of all electricity was generated by hydropower and another major project is underway to develop about 500 MW of capacity.

Jamaica possesses several small hydroplants with a total capacity of 21 MW, out of a total electricity generating capacity of 705 MW. One study of the hydropotential of five river basins concluded that most of these schemes would be uneconomic, even at present high oil prices. However, a feasibility study of a relatively large multi-purpose scheme for hydro-generation and water supply has been proposed. Potential installed electricity capacity has been estimated at 90 MW.

Hydropower potential appears to be very limited in St. Lucia, Grenada and St. Vincent. It is unlikely that any but micro-hydro schemes can be developed. Presently, micro-hydro schemes established in St. Luica provide very small quantities of power. St. Vincent has hydroplants which provide around 60 percent of the total power generated on the island. Hydrological studies in Grenada suggest that hydro-potential is fair, in the light of the island's topography and high rainfall. A feasible prospect has been identified in the Black River area.

While hydro-power prospects seem reasonably good in the Dominican Republic hydrological surveys are necessary to assess the potential. The two major plants at Tavera and Valdesia have a combined capacity of 136 MW, out of a total of about 150 MW of hydro-power capacity. Hydropower capacity accounted for more than 17 percent of the overall electricity generating capacity in 1978. A total of 17 micro-hydro schemes, (of 10-50 MW capacity) have been identified and are to be implemented during the next decade.

In Trinidad and Tobago, hydropower has not been developed because of the existence of hydrocarbon resources. There appears to be potential for micro hydro schemes; however a hydrological survey is necessary to evaluate the full potential.

Thermal Electricity

Thermal electricity accounts for the largest share of final energy consumption in the CDCC region, over 99 percent in 1978. Very few countries, notably Trinidad and Tobago utilize natural gas for electricity generation, most utilize petroleum and none, so far as is known, utilize coal. Data is given in the Statistical Appendix for CDCC countries.

In general, electricity production (and consumption) is highest in the relatively more industrialized of these countries, in countries with petroleum refineries and also in countries that are large producers of major minerals.[1/]

The major sources of fuel utilized in electricity generation are diesel oil, other fuel oil, including "Bunker C", and natural gas (where this is available). The bulk of this fuel is imported from countries outside of the CDCC region. Substantial trade however is conducted between Trinidad and Tobago and the islands of the Eastern Caribbean in petroleum products.

There is substantial variation in the utilization ratio[2/] of thermal electricity from country to country, during any given year. Cuba, Belize, the Dominican Republic and Jamaica have tended to have the highest rates in recent years. Many factors account for the variation: industrial disputes, breakdown of equipment, stoppage for maintenance etc. However, the utilization ratios in the CDCC area compare favourably with similar ratios for the United States, Canada, Brazil and Venezuela - where the ratios range from 2,000 to around 4,000.

With increased economic activities in the region, it is envisaged that electricity production will rise substantially over the next few years, though the extent of expansion will most certainly depend largely on the rising cost of fuel. Definite plans for the expansion of generating capacity have been formulated, for most countries. Trinidad and Tobago and Cuba are in the process of significant expansion of thermal capacity.

1/: See Caribbean Production and Consumption of Energy; (CEPAL/CARIB 78/7)

2/: i.e. the ratio $\frac{\text{electricity generation (kWh)}}{\text{installed capacity}}$

Power companies in the region are largely owned by the Government, but in some countries such as Barbados and St. Vincent, there is still significant foreign and local private ownership. With an increase in the mining and refining activities, these establishments have installed substantial "captive" generation in recent years since the public systems cannot usually meet their power needs, due to their isolated locations and high costs.

Service has deteriorated in several countries, due to technical, managerial and financial problems. Frequent breakdowns prompted some firms to acquire back-up generators, whose operating costs are high.

It is possible that expansion in output could be achieved by replacement of outmoded and depreciated equipment and improved maintenance practices.

Power utilities in the CDCC countries have a common problem, namely, that their financial position is weak. In some cases revenues are too low to cover their operational costs and they are subsidized from government revenues as a conscious policy action.

Fuelwood and Charcoal

Forest resources are one of the most widely available and renewable of energy resources in the CDCC areas; consequently, the use of charcoal and firewood has played a substantial role, traditionally, in the generation of energy in most CDCC countries.

Guyana and Suriname have the largest forested areas in the CDCC region, though several other countries have relatively large forest areas. The problem almost universally throughout the region, has been one of indiscriminate cutting of trees for fuel and non-fuel uses, combined with a lack of re-afforestation efforts, so that there has been considerable deforestation in many countries.

Using relationships derived from one source[4/], operating at 35 percent average efficiency[1/], thermal electricity plants fired by wood, up to a capacity of 100 MW could potentially be supported by forests of a country as small as Dominica. However, this potential is constrained by such problems as accessibility, logistics of logging, transportation and the intensity of cultivation.

Table 3 gives a broad outline of the potential of using the forest as a renewable source of energy. It should be noted that actual yields from forests would be lower than indicated because some areas are not well-wooded.

Energy Potential from Forestry Bio-mass
Selected CDCC Countries, 1976

Country	Forest[26/] Land Area sq km (1)	Energy Potential MW (2)	Present[10/] Electricity Generating Capacity MW (3)	Ratio Col 2/Col 3 (4)
Jamaica	4,920	1,800	685	2.6
Dominican Republic	11,040	3,900	743	5.2
Cuba	12,300	4,400	1,705	2.6
Guyana	181,900	65,000	180	361.1
Belize	10,120	3,600	12	300.0
Suriname	143,500	51,300	361	142.1
Bahamas	3,240	1,200	255	4.7
Trinidad and Tobago	2,260	800	454	1.8
Haiti	2,000	700	89	7.9
Dominica	350	100	6	16.7

In addition to small scale charcoal production, Guyana is in the process of establishing a large scale charcoal industry, for the purpose of producing a standard quality product suitable for export. There are also plans for improving the efficiency of small scale production of charcoal.

In Grenada, there is a project proposal[24/] for commercial forest development in the Grand Etang region. Over 12 percent of this country is forested, and it is expected that this project will increase total charcoal production to approximately 200 tons annually.

In Haiti, about 75 percent of wood harvested is used as a fuel source either directly or for producing charcoal. Considerable deforestation has taken place in Haiti, and in 1975 only about 8.5 percent of the land area was defined as forested compared with 25 percent in 1950.

The abundant resources of other countries, if carefully exploited and combined with a reafforestation programme could contribute significantly to energy supply for a virtually indefinite period.

Before systematic utilization of forest resources can be implemented, certain definitive actions as indicated below should be taken:

(a) A complete survey of forested areas, where such an inventory does not now exist, to determine extent, geographical location, general condition of trees, quantity of which varieties, etc. It will be necessary to update the records periodically.

(b) Institution of conservation and re-afforestation practices urgently, including controlled cutting of trees. Data on Haiti indicate the urgency. Forest and woodland areas were put at an average of 340,000 hectares in 1961-1965, but by 1975 the total was estimated at only 235,000 hectares and is estimated to be completely exhausted by the year 2000 if no conservation measures are taken[25/].

(c) A detailed study of the relative advantage of wood in different uses, for example, as lumber, pulp and paper, crude acteic acid and wood spirit etc. It would be advisable also to do research into the carbonization of various woods. There may not be much choice in some cases since energy is indispensable to modern living. However, it should be borne in mind that variety of trees and their condition are important in some non-energy uses of wood. Selective planting of species can reduce the problem of competing uses.

NON-CONVENTIONAL ENERGY RESOURCES

Five types of non-conventional energy resources some of which are receiving increasing attention, and exist in exploitable levels in the CDCC area are discussed below:

(a) Solar (c) Nuclear (e) Biological Resources

(b) Geothermal (d) Wind

Solar Energy

Solar energy as an alternative source of useful energy, has received the greatest attention in recent times, as it exists on a global basis, in immense quantities, is everlasting and non-polluting. All our energy (except nuclear and geothermal) are derived directly or indirectly from the sun. The total annual solar radiation reaching the outer atmosphere of the earth is some 1.5 x 10^{18}kWh[19/] of which some 1.05 x 10^{18}kWh reaches the earth's surface. One can compare this with the total world energy consumption of some 7.1 x 10^{16}kWh[10/] of commercial energy.

That is to say, that nearly 15 times more solar radiation reaches the earth's surface than the total world consumption of commercial energy. It would appear that Caribbean countries, located as they are in the tropics, may be even relatively better off in so far as solar radiation is concerned.

As can be seen in Table VII of the Statistical Appendix, the solar energy incident on these countries can make a contribution to their total energy requirements.

Despite decades of research in many countries, solar energy has been used on a rather limited scale due mainly to:-

(1) Easy availability, until recently, of relatively inexpensive oil and gas.

(2) The intermittent nature of the energy source, necessitating the use of substantive storage systems with conventional back-up systems.

(3) The diffuse or low intensity quality of the energy source, requiring the use of extensive areas of collection to provide significant quantities of energy.

In direct utilization of solar energy there are three routes possible. These are:-

i) Conversion of solar energy to heat, via flat plate and concentrating collectors.

ii) Conversion of solar energy to electricity via photovoltaic devices.

iii) Conversion of solar energy to biomass prior to conversion to any of their end-use forms.

Presently, solar energy is used in the Caribbean for crop drying, water purification, heating and distillation, but as yet only on a limited scale. Two solar stills have been built by a foreign research institute in Haiti and Petit St. Vincent in the Eastern Caribbean. These stills have been successfully used to provide potable water to small rural communities. Solar crop-dryers have been built in Grenada for drying nutmegs and in Barbados for sugar-cane. Considering that most CDCC countries are highly dependent on agriculture, and in view of the lack of proper irrigation facilities, the development and introduction of water-pumps powered by solar energy for village supplies, livestock and irrigation could be an objective for the short-term in CDCC countries. Other possible areas for the immediate use of solar energy via the thermal process in which moderate temperatures of up to $150^{o}C$ are required, are water-heating, water desalination, solar-heating for domestic and commercial hot-water and industrial process heat and small vapour plants for rural electrification. Vital areas in which solar energy utilization could perhaps have the greatest impact, include cooking and the tourist industry, where there is large scale use currently of high cost electricity.

Certain solar technologies are now sufficiently well developed, to be widely deployed in the CDCC region. In particular, the technology for the application of solar energy to water heating recahed a satisfactory level of development in Jamaica and Barbados in the latter of which, two companies[15/] are engaged in the manufacture of solar water heaters. The Barbados Government is giving active encouragement to the development and use of solar energy for water-heating and air-conditioning by use of the tax system. Air-conditioning powered by solar energy is to be used in the New Administrative Building of the Ministry of Agriculture and the Central Agronomic Research Laboratory.

This prolific energy source can be optimally utilized (in several other countries) if adequate quantitative data on the radiation levels are collected. At present, such data is lacking for most islands and it would appear that a wider network of measuring locations is necessary in most countries of the CDCC region, for a fuller evaluation of solar energy potential.

GEOTHERMAL ENERGY

The temperature of the earth's core is about $4000^{o}C$. In some parts of the world, especially where there is volcanic activity, this natural heat occurs near the surface at relatively high temperatures.

Geothermal energy is the use of steam or hot water from such sources for generating electricity. Everywhere beneath the earth's surface, temperature increases with increasing depth, but the average figure for the rate of increase with depth is only $15^{o}C$ per kilometer. The rate of increase may be more than a hundred times higher, in areas of volcanic activity within recent geologic times.

The volcanic origin of some of the CDCC countries offers the possibility of potential geothermal energy resources Dominica, Montserrat, St. Lucia, St. Vincent and, to a lesser extent, the Dominican Republic, Grenada, Haiti and Jamaica where hot springs occur, are the possible sources for exploiting this energy resource.

Preliminary analysis of the geothermal source of power at Soufriere in St. Lucia, indicated a potential energy capacity of 10 MW. [*/] The use of geothermal sources for steam and power generation, could give the smaller countries a significant economic boost. However, the major constraint on developing geothermal energy in the region is the lack of finance.

In 1969, a UN study was done in Dominica, where the extensive surface manifestations make geothermal potential quite apparent.[11/] Several areas have been suggested for further studies since 1969, but more up-to-date data are unavailable. It appears that those geothermal manifestations in Jamaica are insufficient for power generation, while for Haiti and Grenada it will be necessary to determine the origin of the hot springs, i.e. whether geochemical or geothermal, before any exploratory drilling is effected. A study of the possibility of the geothermal electricity generation was underway in the Dominican Republic during 1979.

Some success has attended the preliminary exploration for geothermal steam in St. Lucia and there are optimistic expectations about future

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*/: See Table IX

possibilities. Seven wells were drilled during 1974 to 1976, two of which produced dry steam at very shallow depths, a steam flow the equivalent of about 1MW of power generating capacity.

In the remaining countries, either no geothermal survey or only preliminary exploration has been carried out.

Recently, studies have been done into the possibility of tapping the thermal energy of hot magma, by passing water through suitably porous or fractured magma to obtain steam for power generation. Tapping of the magma should be a good proposition for the volcanic islands of the Caribbean.

Geothermal fields produce steam at relatively low pressures, hence the power generating units tend to be of much lower capacities than those in a modern nuclear or fossil fired installation. This is of particular advantage to the CDCC countries in which geothermal potential exists since their power needs are comparatively low. Hence low pressure power generating units can be established to sustain their energy needs.

Geothermal energy has some environmental disadvantages, with gases such as carbon monoxide and traces of hydrogen sulphide polluting the atmosphere. However this problem can be minimized with the appropriate expertise and resources.

It is worth emphasizing that to date little attempt has been made at the utilization of geothermal energy for purposes of power generation. In the context of the CDCC countries, it would be worthwhile examining the possibility of using geothermal hot water in areas such as crop-drying, water-heating, absorption refrigeration systems and food processing. Since this type of energy source produces cheaper electricity than coal or oil, there should be thorough investigations wherever there are positive indications.

Nuclear Energy

The basic fuels for nuclear reactors are uranium (235), a naturally occuring isotope which can sustain a chain reaction, plutonium (239) and uranium (233) both by-products of nuclear reactors. Effectively, therefore, consideration of nucelar energy resources in the CDCC area is limited to uranium ores. Natural uranium contains about 0.7 percent of U_{235}. One kilogram of Uranium-235 will produce about 24×10^6 kWh of heat. Thus a power station rated at 1000 MW and operating at a thermal efficiency of 33 percent, will require about 160,000 kilogrammes of natural uranium a year.

So far, there is little evidence of the availability of uranium ore in the CDCC region. However, surveys carried out in the Pakoraima mountains of Guyana, for uranium deposits gave favourable indications, though the quality and extent of these deposits are not yet known. Extensive surveys conducted in Jamaica in 1950 for uranium ores proved fruitless.

There is need for more systematic geological surveys in CDCC countries. Furthermore, countries may need to consider the possibility of purchasing nuclear power plants. In both instances, there will have to be dependence on foreign technology but the possibility of discovery and the high cost of conventional energy justify at least investigations in suitable locations. Capital will be a problem in either case, but more so for the purchase of plants as only few countries, notably Trinidad and Tobago, can afford a nuclear plant at present. It may be noted that Cuba has plans for opening its first nuclear energy plant and with this in mind, an electrical nuclear institute was scheduled to begin operations in 1978 for the training of intermediate level and other personnel.

In the other CDCC countries, very little is known of the plans for the utilization of this form of energy, though it has been reported that the Government of Trinidad and Tobago has signed with the French Government, a technical-economic agreement which includes the development of nuclear power.

Clearly of all alternate energy systems, the nucelar reactors are the only ones at the commercial stage in so far as large scale power production is concerned. The crucial problems associated with nuclear fission are the inherent dangers associated with radiation leaks and the disposal of radio-active wastes.

Although nuclear power can supply our energy requirements, it raises the spectre of proliferating nuclear weapons capacity and fears of radioactive pollution. Another serious problem will be the lack of awareness and expertise in nuclear technology, and high capital outlay initially.

Wind Energy

The winds are a direct result of the sun's radiation. It has been estimated that between one and one and one half percent of the incoming solar energy is converted to kinetic energy manifested in winds.

The availability of wind energy in some CDCC countries can be gauged from monthly average windspeed values, (See Table VIII of Appendix) which indicates that several islands show potential of being suitable for the utilization of wind energy.

The advantages of harnessing wind power through the use of windmills is that mechanical power is available directly, and could be used for driving irrigation pumps, vapour compression, refrigerators and other equipment.

Their main disadvantages, are that windmills need a steady wind supply, and that their energy is difficult to store for use in calm periods. Although it would take quite a lot of windmills to equal the output of a conventional power station, they offer a form of cheap, decentralized energy.

To develop the ancient but effective energy form, especially for decentralized power, much more data on wind speeds, and their variations need to be collected. It should be borne in mind that most CDCC countries are subject to hurricanes, which would influence the design of the wind machines.

The CDCC countries have had long experience in using wind as a source of energy. Prior to the introduction of machinery for crushing sugar cane, small factories were situated on elevated land, in order to use the available wind for driving windmills, for crushing the cane. This is true for Jamaica, Antigua and Barbados. (Fishing boats were powered by wind[15/], in Barbados, before the introduction of engines during the 1950's). Additionally, before the island-wide availability of electricity, storage batteries, which provided electricity for a number of individual households, were recharged using wind energy.

Clearly, therefore, wind forces are of sufficient magnitude for useful energy to be extracted from them. In order to assess the wind energy potential of CDCC countries, a network of wind measuring stations, need to be established throughout the region to facilitate comprehensive measurements of wind regimes, and wind characteristics, since this type of information base is presently unavailable. Once the local wind regimes are understood, engineering of traditional horizontal axis windmills would be quite easy.

Already the Barbados-based Caribbean Meteorological Institute is an active participant in collating information on wind speeds, for most CDCC countries. In addition country studies have been done on the assessment of wind potential in some CDCC countries, however follow-ups on these are necessary, for immediate implementation of this resource.

The utilization of wind as a power source is still in its experimental stage, in this region, but due consideration should be given to harnessing this energy for such applications as water-pumping domestic lighting, and small scale irrigation schemes.

Biological Energy Resources

One particular energy source which, because of its complex and diverse nature, has many linkages with other activities such as agriculture, health, waste removal, sewage treatment etc., is the generation of bio-gas from biological sources. This energy source will be discussed under three subsections: biogas, gasohol and utilization of agricultural wastes. (Charcoal and fuelwood were included in the section on Conventional Resources.)

Production of Biogas

Biogas is produced when organic wastes, manure, vegetable matter and human waste are decomposed by bacterial action in anaerobic conditions as found in an airtight digester. The biogas produced has a composition of approximately 55 - 65% methane (CH_4), the gas which forms 95 percent of natural gas, 35 - 45% carbon dioxide (CO_2), and traces of oxygen, nitrogen and hydrogen sulphide. It is combustible with a calorific value of 20,000 to 25,000 KJ/m^3 (2.0×10^4 to 2.5×10^4 KJ/m^3), and can substitute as an energy source for cooking, heating and refrigeration. Once the gas production has ceased in the digester, the residue forms an excellent fertilizer.

This process of biogas production is particularly advantageous in several ways. It is simple, and reduces the health hazards associated with the handling and disposal of plant and animal wastes. The gas can be stored and used as required, and the raw materials used are renewable natural resources.

Among the most successful materials so far identified for biogas generation are:

- Crop wastes, e.g. sugar cane trash, spoiled foods, food rejects.
- Waste from aquatic environments including seaweeds and freshwater weeds.
- Forests, parks and garden litter i.e. leaves, twigs, saplings etc.
- Agro-industrial wastes e.g. rice bran, press mud from sugar factories, vegetables and fruit processing.
- Animal wastes i.e. faeces, urine, garbage etc.

Data on selected cities in the CDCC area are given in Table 4 below. The figures on human waste are for 1970, and relate to the greater city areas which may not all be linked at present to one central sewerage system.

However since 1970, urban populations have increased in several countries of the region, such that potential energy generation in 1979 can be said to be higher than the figures shown in the table. The possible production of electricity from this source for some major cities is sizeable, compared to the 1976 electricity generation; 18 percent in the case of Haiti and for Guyana 3 percent. Obviously, if central sewer systems existed in all major cities the real potential would be considerably greater.

TABLE 4

Crude Estimates of Possible Energy Potential of Human Wastes in Selected Countries, 1970

Country	City	Population	Estimated Annual Biogas Production '000 m^3	Million*/ kWh
Cuba	Havana	1,751,216	20,071	44.9
Dominican Republic	Santo Domingo Santiago de los Caballeros	817,645)) 245,165)	12,181	27.2
Haiti	Port au Prince	(1971) 493,932	5,661	12.7
Guyana	Georgetown	164,039	1,880	4.2
Jamaica	Kingston	475,548	5,450	12.2
Trinidad and Tobago	Port of Spain	67,867	778	1.7

*/: Operating at 33 1/3% efficiency.
Population figures are for 1970 with the exception of Haiti.
Source: No. 30 of List of References.

It is estimated[27/] that the manure from one large dairy cow could yield 2.5m^3 of biogas per day, roughly equivalent to one-third a gallon of gasoline. On this estimation Table 5 has been compiled, to show the potential energy production from livestock in the CDCC region as a whole.

TABLE 5

Animal	Average Annual[26/] Population (Million) (for period 1975-1977)	Total Waste[*/] Yr: tonnes/head	Estimated Energy Potential per ton (kW)
Cattle	9.0	13.4	2.4
Hogs	4.5	1.7	0.28
Sheep	0.8	0.93	0.2
Poultry	87.9	0.40	0.1
Horses	...	7.4	1.4

*/: Include liquid and solid wastes.
Source: No. 27 of References.

It has been estimated that wastes from 1,000 poultry broilers "will be capable of producing about 10 m^3 of methane per day, an energy equivalent of 100 kWh per day." If one assumes 30 million broilers, the potential energy equivalent to the methane produced will be 3 million kWh per day. Jamaica[28/], at present has one unit, generating methane from animal wastes.

Minicipal wastes and their disposal is becoming a bigger problem every year, with the continued urbanization of the CDCC countries. It may therefore be possible to make a substantial contribution to alleviating both the energy and waste problems, by converting the latter to biogas for energy uses. The estimated energy potential for selected countries is given in Table 6.

TABLE 6

Estimated Energy Potential from Municipal Wastes in Selected CDCC Countries, 1976

Country	Estimated Annual Municipal Wastes ('000 MT)	Total*/ Calorific Value (million kWh)	Total Electricity[10/] Generation (mill. kWh)
Barbados	44.5	29	228
Cuba	2489.8	1613	7198
Dominican Republic	872.1	565	2690
Guyana	144.9	94	390
Haiti	832.0	539	209
Jamaica	365.3	237	2378
Suriname	78.5	51	1335
Trinidad and Tobago	192.4	125	1367

*/: Operating at 33 1/3 percent efficiency

Gasohol (Gasolene - alcohol fuel)

The rapidly increasing prices for gasolene make it possible that the production of alcohol from biomass as a source of fuel, which was previously too costly, may now be quite economic and may serve to decrease fuel import bills.

The fundamental attraction of alcohol motor fuel as a substitute for fossil fuel lies in the fact that on account of its chief sources being found in the vegetable world, supplies of raw material for its manufacture are being constantly renewed.

Raw materials feasible for alcohol production include cassava, tubers, sugar-cane, cereals and bananas. Table 7 below summarizes the results of a comparison of some of these materials.

TABLE 7

RAW MATERIAL FOR ETHANOL PRODUCTION, SELECTED DATA

Material	Yield MT/Acre*	Production Cost (US $) (per acre)	Ethanol Yield Litres/Acre
Cassava	2.94	140	897
Sweet Potatoes	3.67	140	1,119
Potato	4.40	450	1,166
Sugar-cane	20.57	100	1,337

* : 1 Acre = 4047 sq. metres
Source: No. 23 of List of References

The above table compiled from agricultural data for the Dominican Republic shows clearly that the sugar-cane is probably the most suitable feedstock for alcohol (ethanol C_2H_5OH) production, since it has the lowest cost and the largest yield of ethanol per unit area. Further, this crop is cultivated widely, and the sugar production technology is relatively simple and well known in CDCC countries. Today, there remains an excess of cane after every harvest in most countries, which can be absorbed by the production of alcohol. Molasses, a by-product of sugar, is also considered as (raw material for) ethanol production, however this commodity has a number of competitive uses and a growing demand. It has also been established that the cost of producing ethanol directly from sugar-cane is not appreciably higher than that from molasses.

Consideration needs also to be given to the properties of ethanol which make it a suitable fuel for present-day combustion engines. Table 8 below, compiled for the Dominican Republic lists some pertinent properties of ethanol and gasolene.

The heating values by themselves, show that ethanol appears to be a much poorer fuel than gasolene. However, the remaining properties, partly compensate for this drawback, to the extent that on a volume basis ethanol's specific consumption is only marginally higher than that for gasolene. This is so because the larger heat of vaporization allows for a more efficient heat exchange, while the higher density affords a greater heating value per unit volume. The higher octane number of ethanol permits a much higher compression ratio which implies better fuel efficiency.

TABLE 8

COMPARISON OF CERTAIN PHYSICAL PROPERTIES OF ETHANOL AND GASOLENE

Fuel	Heating Value (kcal./kg.)	Heat of Vaporization (kcal./kg.)	Density (kg/l at 20°C)	RON
Ethanol	6,400	216	0.79	106
Gasolene	10,500	100	0.74	95

RON refers to the "Relative Octane Number"
Source: No. 23 of list of references

A mixture of 20 percent ethanol in gasolene is hardly different from pure gasolene, and bearing in mind that ethanol is miscible with light hydrocarbons in all proportions, there is no need to modify the carburation of normal vehicles.

Before processing agricultural raw materials into alcohol for use as an energy source, one must consider the economics of the power alcohol industry. For the production of surplus sugar-cane all countries would have to utilize more land area in order to increase production. This land would have to be relatively flat to facilitate intensive mechanization so as to be as cost efficient as possible. Two immediate problems arise: the unavailability of large quantities of flat land and of investment funds.

Present industry economics necessitate large scale production and there is a scarcity of flat land and finance in most CDCC countries. Some preliminary analysis of the possibilities for the industry in Guyana and Jamaica around 1978-79 suggested that at their prevailing prices and the state of the arts, ethanol production would be more costly than petroleum, even if the quantity of land were available and that therefore ethanol was at a relative disadvantage vis-a-vis sugar and its traditional by-products.

Agricultural Wastes

BAGASSE

Sugar-cane is grown in all the countries of the CDCC and in relatively large quantities in the countries shown in the table below. One researcher[22/] indicates that sugar factories in Haiti are able to satisfy all their energy requirements from bagasse, the fibrous residue after juice is extracted from the sugar-cane. Considerable use is made of bagasse as fuel in other countries including Guyana, Barbados and Jamaica.

The energy content of dry bagasse, is put at 5.15 kWh/kg[4/]. The results of calculations shown in Table 9 below indicate tremendous potential based on utilizing all the available bagasse. From the table below it will be seen that even at 33 1/3 percent efficiency, the potential electricity that could have been produced from bagasse in 1976 exceeded the total electricity generation of six CDCC countries. Hence serious investigations should be undertaken as to the utilization of surplus bagasse for electricity production. In fact it would not be too far-fetched to suggest that sugar-cane could be grown for its use as fuel, not only for bagasse but for motor alcohol.

TABLE 9

Estimates of Potential Energy Yield from Bagasse
Selected CDCC Countries, 1976

Country	Total Estimated Bagasse Yield*/ ('000MT)	Total Energy Potential (Mill.kWh)	33 1/3% Efficiency of Energy (Mill.kWh)	Total Electricity Gen. (Mill kWh) 10/	Col. 4/ Col. 5
Barbados	138	710.7	236.9	228.0	1.04
Cuba	7,800	40,170.0	13,390.0	7,198.0	1.86
Dominican Republic	1,640	8,446.0	2,815.3	2,690.0	1.05
Guyana	615	3,167.3	1,055.7	398.0	2.65
Haiti	417	2,147.6	715.9	209.0	3.43
Jamaica	544	2,801.6	933.9	2,378.0	0.39
St. Kitts, Nevis, Anguilla	48	247.2	82.4	23.0	3.58
Trinidad and Tobago	348	1,792.2	597.4	1,367.0	0.44

*/: Calculated using the relationship that for every ton of sugar produced, one and a half tons of bagasse is produced.

Although the above statistics indicate possibilities for increased use, there are some constraints on greater utilization of bagasse for energy requirements:-

i) Sugar production has been declining substantially in some countries, and substantial new plantings would be required.

ii) By burning bagasse the soil is deprived of valuable fertilizing materials.

iii) Boilers need to be designed, so as to produce electricity more efficiently from bagasse.

iv) The alternative uses of both sugar-cane and bagasse, that is, in the manufacture of molasses, alcohol, fibre-board,animal feed, paper etc.

The maximum utilization of bagasse as an energy source would depend on decisions concerning some factors or combination of the factors listed above.

RICE CHAFF

Rice chaff, obtained as a residue after harvesting paddy, is presently burnt in Guyana[29/] boiler furnaces for the production of electricity in rice mills. Since rice is another major crop of the CDCC areas, and the the potential energy yield utilizing a ratio of 0.25 chaff to paddy is 12.77MJ/kg, rice chaff can be used quite successfully for supplementing energy needs in rural areas, where it could be utilized directly on farms, mills, etc.

Another advantage of utilizing rice chaff, lies in the fact that the residue of the combustion of rice chaff is about 20 percent of the original weight of chaff, and is known as pozzolanic silicate ash, which can be used as a cement extender in motars. However, before this becomes a reality, furnaces must become adapted to allow complete combustion of the rice chaff. The proper incinerator of chaff at mills is therefore capable of generating savings in expenditure for fuel, as well as an income from an otherwise valueless material, the pozzolanic ash.

Table below shows the potential energy obtainable from the full use of rice chaff for electricity generation. As more rice is grown as part of the self-sufficiency in food programmes being espoused in several CDCC countries, more chaff will become available hence more power generation will be possible.

It is obvious that the potential energy yield from rice chaff is not as impressive as from bagasse and certain other sources. However, it is equally clear that there are conditions under which energy from rice chaff could be a viable possibility. Significant possibilities would seem to exist for direct utilization on farms, in rice mills and in their immediate environs. In certain rural areas utilization of rice chaff for energy may be the only possibility for electrification.

Best possibilities would seem to exist in the larger rice producing countries but this does not preclude smaller countries or current non-producers, looking at the feasibility especially in conjunction with agricultural expansion in this era of high petroleum prices.

TABLE 10

Rice (Paddy) Production and Potential Energy Yield - 1977

Country	Rice Production 26/ ('000 MT)	Estimated Chaff ('000 MT)	Energy Potential (Mill kWh)	Total Electricity Generated (Mill kWh) 10/
Belize	5.0	1.3	4	46
Cuba	420.0	105.0	372	7,700
Dominican Republic	277.0	69.3	246	2,671
Guyana	356.7	89.2	316	416
Haiti	100.0	25.0	89	215
Jamaica	5.6	1.4	5	2,100
Suriname	198.8	49.7	176	1,421
Trinidad and Tobago (1976)	20.0	5.0	18	1,367

Other Agricultural Wastes

Agricultural waste is much more attractive as a fuel. There are some CDCC member countries such as Belize, Guyana and Haiti, which have thriving timber industries. Much of the sticks, edgings, sawdust etc., from this industry is burnt as waste or dumped. These could be utilized to supply a portion of the electricity needs, in those forested areas. Other agricultural waste such as palm nut shell, soya bean, coconut husks, can be used to produce charcoal with moderate scale technology, utilizing also used wastes, forest thinnings, saw-mill off-cuts, sawdust and shavings. These materials produce a solid fuel with a carbon content of the order of 80 percent better than household coal and equal to metallurgical coke. The fuel is valuable, not only because of its capability of producing high temperatures, and reducing atmospheres, required for the smelting of metallic ores but also because in briquette form, it forms an efficient domestic fuel.

With these possibilities in mind, serious efforts need to be undertaken now to investigate the possibility of utilizing these various crop-waste in producing energy.

TABLE I

CRUDE PETROLEUM AND NATURAL GAS EXPLORATION

Country	Geophysical Activity (crew-months 1978)	No of Exploratory and Development Wells Drilled		No of Petroleum Producing Wells		Area Allotted for Exploration	Remarks
		Land	Marine	Land	Marine		
Belize	4	35 (total)		-	-	2.5×10^6 hectares. Of this 22,000 sq km on-shore.	Exploration was intensified during 1979. There appears to be a prospective hydro-carbon-bearing area in Belize, 6,000 sq mls on-shore and 5,500 sq mls off-shore.
Bahamas	28	4 (total)		-	-	Prospective area for hydro-carbon drilling includes 11,000 sq km on-shore and 260,000 sq km off-shore.	
Cuba	...	...		...	...	...	Production during 1978 was: 10/ Crude Petroleum - 0.050×10^6 MT Natural Gas - 0.220×10^3 Tcal.
Dominican Republic	23	40 (total)		2	-	Exploration permits were granted to five foreign firms during 1977 for hydro-carbon exploration over 10,000 sq km on-shore and 90,000 sq km off-shore.	Started production of crude petroleum during 1978 (1,440 barrels per day), and has potential reserves at 200×10^6 barrels. There are five possible oil-bearing basins over approximately 17,500 sq km. Gas shows were reported in Enriquillo basin.

T A B L E I Cont'd

CRUDE PETROLEUM AND NATURAL GAS EXPLORATION

Country	Geophysical Activity (crew-months 1978)	No. of Exploratory and Development Wells Drilled		No. of Petroleum Producing Wells		Area Allotted for Exploration	Remarks
		Land	Marine	Land	Marine		
Grenada	1	-		-	-	...	A Survey on the south-western off-shore region has been done with promising results. No indications on the extent of the reserves are available.
Haiti	-	11 (total)		-	-	Reports of contract with oil exploration firm (1977) 1.8 million acre concession granted to three oil companies.	Existence of favourable geological structures for reservoirs and creation of stratigraphic pockets. Wildcat land and marine drilling is in progress after a series of gravimetric surveys were done. Three off-shore wells gave negative results.
Suriname	26	34 (total)		-	-	10,000 sq km on-shore; 120,000 sq km off-shore. Contract for exploration granted during 1977.	Estimated potential reserves of 270 x 10^6 barrels.

NB: SEE ATTACHED ADDENDUM FOR EXPLORATION ACTIVITY IN OTHER COUNTRIES.

Sources: 9, 11, 17 of Lits of References and data supplied CEPAL.

ADDENDUM TO TABLE I

PETROLEUM AND NATURAL GAS EXPLORATION

B A R B A D O S

Geological Indications [21/]

The rocks which enter into the structure of the island are classified as follows:

a) Coral Limestone b) Oceanic Series c) Scotland Beds.

The Scotland Beds from the core of the island and consist of coarse grits, brownish sands, dark sandy and mottled clays, which are in places, saturated with petroleum and contain lenticular beds of asphalt. These beds are folded and broken by many faults, and belong to the Oligocene Series; these beds are the great oil-bearing series of the island.

There are outcrops of unconformities of Eocene and younger formations with oil and natural gas seepages.

Resources

Crude Petroleum ('78)	:	2×10^6 barrels
Natural Gas	:	2.5×10^6 cu ft
Number of natural gas producing wells ('78)	:	4
Number of petroleum producing wells ('78)	:	25
Geophysical Activity 1978 [11/]	:	15 crew months
Number of exploratory and development wells	:	51 (1950-1978)
Production [10/] 1978		
Crude Petroleum	:	0.035×10^6 MT
Natural Gas	:	0.070×10^3 Tcal

Exploratory Activities [17/]

The possibility exists of increasing current production from Eocene sands with increased development input. Under active consideration, is a programme to carry out an aeromagnetic survey and seismic surveys, to more accurately determine the areas of possible production from Eocene and older formations.

Probable reserves will depend on geological and geophysical studies currently being undertaken.

Development drilling was intensified during 1977. In 1978,[17/] BDS$10.4 million was spent on drilling twelve new exploratory wells in the Woodbourne, St. Phillip area; six more wells are expected to be drilled during 1980. There has been some indication of a possible oil source in St. Andrew Parish but this has to be confirmed.

The Government has approved a series of seismic tests for off and on-shore exploration which are expected to be completed during 1980. (200 sq km on-shore and 10,000 sq km off-shore).

G U Y A N A

Geological Indications [21/]

The country structurally belongs to the great Brazilian massif of ancient crystalline rocks.

The coastal belt consists of post-Tertiary accumulations while the western and central areas are occupied by a great sandstone formation rising in the Pakaraima Mountains with perpendicular cliffs and plateaux. The rest of the country is composed of the ancient crystalline rocks. The low lying areas consist of alluvial sands, clays and gravels of recent origin.

Number of exploratory wells drilled [11/]

Land	:	8
Marine	:	5

Geophysical Activity [11/] (1978) : 15 crew months

Exploratory Activities [17/]

Almost all of the off-shore region and some on-shore areas have been earmarked for hydro-carbon exploration. In previous years thirteen wells were drilled (eight on-shore and five off-shore), some of which were reported to have given minor hydro-carbons shows.

The Government has signed oil-prospecting contracts with three foreign companies. One included a 4,390 sq miles concession, twenty miles off-shore between the mouths of the Corentyne and Demerara Rivers, to explore for oil and gas. The second concession includes 900 sq mile tract in the Takutu Basin in the south west Rupunini region, and the third includes exploration off-shore in the Berbice region.

If oil and gas are found in commercial quantities, the Guyanese Government will enter into further contracts, for the development drilling phase with these foreign companies.

J A M A I C A

Geological Indications [20/]

Jamaica with an on-shore area of 11,420 sq km and off-shore area of 9,512 sq km has had a geological history since middle Campanian time (period during the Upper Cretacious Time), which makes several areas on-shore and off-shore feasible for future hydro-carbon exploration.

The oldest rocks in Jamaica appear to be medium to high grade metamorphic rocks of the south-western Blue Mountains block, and the south-east Clarendon block. These rocks appear to have been engeo-synclinal volcanic and intrusive bodies, associated with sedimentary strata, and silicic plutons. There are no higher grade metamorphic rocks in Jamaica.

The yellow limestone group, of late - early to early-middle Eocene age, transgresses all of the older strata. This group covers the rugged topography that was developed on pre-late early Eocene rocks. The lower part - the Guy's Hill member and its equivalents contains conglomerate sandstone, siltstone and shale, commonly with beds of lignitic shale. This shale is organic and could have acted as both source and seal for hydro-carbons. It is possible also that the lignite and lignitic beds could have provided a source for gaseous hydro-carbons. The sandstone beds of the Guy's Hill locality are very tight; in other areas they are porous and permeable. The basal part of the yellow limestone group is considered as being a prime exploration target.

The yellow limestone group grades upward into the white limestone group, of the late middle Eocene through the middle Miocene age. It is the principal surface formation of Jamaica, covering 60-70% of the surface. This area is not considered to be a major hydro-carbon objective, because there are few or no seals. However, south of Jamaica, on the off-shore and Pedro Banks, the white limestone group is overlapped by a section of younger sediments. It is believed that hydrocarbons may be preserved off-shore within these sediments. Minor gas shows were recorded on Pedro Banks which forms part of this section called the Troy Formation.

Number of Exploratory and Development wells drilled (1978)

Land	:	6
Marine	:	1

Geophysical Activity 11/ (1978) : 16 crew months

Exploratory Activities 17/

A J$50 million exploration programme was initiated during 1978, and is expected to be completed during 1982.

A US$1.6 million off-shore geophysical survey done by a foreign company two years ago (1978) indicated that oil might be present in commercial quantities in such areas as Pedro Banks, Negril, Montego Bay and Savanna-la-Mar. 9,000 sq km have been earmarked for exploration on-shore and 200,000 sq km off-shore.

An oil trace was found in the Windsor Area of St. Ann at a depth of approximately 46m while there was a gas show at Negril.

TRINIDAD AND TOBAGO

Geological Indications 21/

Petroleum and asphalt are widely distributed through the Tertiary rocks and occasionally the Cretaceous beds are impregnated by oil derived from them. The oil occurs on several horizons. The lower Tertiary oil-sand occurs in the Galeota Group; the Rio Blanco petroliferous beds are in the middle Tertiary, and the La Brea oil-sands in the upper Tertiary of Cunningham Craig's classification. The oil-bearing areas are situated on a series of anticlines, running across the island from east to west and their course is also marked frequently by escapes of gas, outflows of asphalt and mud volcanoes. The Pitch Lake of Trinidad, in La Brea is connected with the development of these beds, and is situated on the denuded summit of a gentle anticline running roughly east and west, forming a shallow basin.

Reserves

Crude Petroleum (proven) (1978)	:	750 x 10^6 barrels 18/
(Proven, possible and probable)	:	1200 x 10^6
Natural gas 18/	:	12 trillion cu ft
Production 1978 p		
Crude petroleum	:	12,000 x 10^6 MT
Natural gas	:	22,880 (1,000 Tcal)
Number of petroleum wells (1978)	:	165
Geophysical activity	:	...

Exploratory Activities

The Government has been encouraging the private sector and state-owned oil companies to accelerate their exploration programmes in new fields, since their proven, probable and possible reserves (1,200m barrels) is expected to last for only sixteen years. The TRINTOC and TRINIDAD-TESORO companies spent about TT$52 million each on exploration on and off-shore during 1979, with encouraging results.

Both oil and gas discoveries were located in an off-shore field at east Galeota; while on-shore, several new exploratory wells have been drilled by TRINTOC, the state-owned oil company.

TABLE II

PETROLEUM REFINING CAPACITY AND PRODUCTION OF ENERGY PETROLEUM PRODUCTS

Country	1960		1970		No. of Refineries	1978	
	Capacity mill MT	Production mill MT	Capacity mill MT	Production mill MT		Capacity mill MT	Production mill MT
Antigua	-	-	-	0.395	1	0.900	0.147 1/
Bahamas	-	-	10.000	2.260	1	26.750	9.100
Barbados	0.050	0.011	0.150	0.114	1	0.175	0.174
Cuba	4.880	3.100	4.340	4.153	3	6.350	6.340
Dominican Republic	-	-	-	-	2	2.300	1.223
Jamaica	-	-	1.500	1.478	1	1.850	1.082
Netherlands Antilles	40.000	34.565	40.000	42.600	2	40.100	26.900
Trinidad and Tobago	12.000	10.348	20.800	20.904	3	23.050	13.365

1/ 1975 figure; refinery inoperative in 1978.

Note: Refinery capacity refers to petroleum refining distillation capacity. The theoretical maximum capability of all crude distillation plants available for operation as at the end of the year stated.

Source: World Energy Supplies, 1973-1978, United Nations 1979 (No. 10 of references.)

TABLE III

COAL

COUNTRY	RESERVES: Proved	RESERVES: Indicated	RESERVES: Inferred	LOCATIONS	INDICATIONS	EXPLOITATION	REMARKS
Jamaica	Not yet assessed		30-3000 x 10^6MT to a depth of 60m or more includ-ing lig-nitic coal and peat	Several in the western section of the island - Parish of St. James, St. Elizabeth and Trelaway	Manifestation of seam thickness up to 2m with a possibility of deep extensions	On limited scale as coking fuel. Studies under-taken by Irish Peat Authority and Ewbanks Engineering	Reconnaissance survey apparently made in 1974. Calorific value of lignite samples 6.44 - 14.8 MJ/kg Studies presently done will include a detailed mapping and quality of categoriza-tion of reserves
Haiti	Lignite extensive. The extent not known. High grade coal non-existent. Maïssade deposits estimated at 13 x 10^6MT			Deposits in Camp Perrin and Maïssade		UNDP-financed study done. One company has been granted a conces-sion not yet known if concession is taken up.	Deposits at Camp Perrin have higher calorific value than those at Maïssade how-ever immediate utilization is constrained by their remote location. Feasibility of a 30MW thermal plant based on Maïssade lignite is being studied
Dominican Republic	Indications of lignite deposits in various areas with seams reaching a thickness of 1m						Systematic exploration has yet to be undertaken
Guyana	Small deposits of lignite have been discovered						Economic viability appeared doubtful

TABLE III (CONT'D)

COAL

COUNTRY	RESERVES			LOCATIONS	INDICATIONS	EXPLOITATION	REMARKS
	Proved	Indicated	Inferred				
Trinidad and Tobago	Several deposits of lignite have been located in various parts of the country			Central and southern Trinidad. Southern Tobago.	Seam thickness from 0.305m to 2.45m. Samples have 60% carbon and low ash		Studies need to be undertaken in order to establish exploration feasibility.

NB: Non-inclusion of countries does not indicate absence of coal only lack of data for those countries.

Source: Data supplied CEPAL.

TABLE IV

ELECTRICITY: INSTALLED CAPACITY AND PRODUCTION

Country	1970 - Installed Capacity			1970 Production ('000mill kWh)	1978P - Installed Capacity			1978P Production ('000mill kWh)
	Total	Hydro ('000 kW)	Thermal		Total	Hydro ('000 kW)	Thermal	
Antigua	14	-	14	0.030	26	-	26	0.053
Bahamas	174	-	174	0.489	255	-	255	0.675
Barbados	39	-	39	0.149	105	-	105	0.266
Belize	8	-	8	0.023	14	-	14	0.049
Cuba	1,400	44	1,356	4.888	1,876	46	1,830	7.750
Dominica	5	3	2	0.007	6	3	3	0.016
Dominican Republic	327	16	257	0.082	900	150	750	2.763
Grenada	5	-	5	0.015	7	-	7	0.028
Guyana	160	2	160	0.344	180	-	180	0.425
Haiti	43	-	43	0.118	102	47	55	0.276
Jamaica	405	21	384	1.542	705	15	690	2.130
Montserrat	3	-	3	0.005	4	-	4	0.010 1/
Netherlands Antilles	286	-	286	1.289	290	-	290	1.750
St. Kitts-Nevis	6	-	6	0.016	13	-	13	0.027
St. Lucia	7	-	7	0.018	15	-	15	0.050
St. Vincent	4	2	2	0.013	9	2	7	0.020
Suriname	260	180	80	1.322	390	200	190	1.540
Trinidad and Tobago	334	-	334	1.202	454	-	454	1.640

1/ Data for 1979

Source: No. 10 of List of References and data supplied CEPAL.

TABLE V

SELECTED DATA ON HYDRAULICS/HYDROPOWER

Country	Major Rivers			Rain fall			Remarks
	Name	Length (km)	Flow Rate	No. of Measuring Sites	Mean Annual Low (mm)	Mean Annual High (mm)	
Antigua	None	-	-	...	660	1651	Data available for 1965 to 1976
Bahamas	None	-	-	124	671	1547	Data refers to period 1977
Barbados	Few streams	-	-	49	1016	2032	Average for period 1847 to 1977
Belize	Belize	...	21(m^3/s)	36	1270	4318	Data given for 1978
	Sibun	...	113(m^3/s)				
	Macal	...	...				
	Río On	...	...				
Cuba	...	...	...	...	810	1309	Data given for 1976
Dominican Republic	(See also Table VI)	...	...	...	372	2021	Data given for 1977
Dominica			(MGPD)	...	1651	2540	Data given for 1975, data are available for period 1965-1976. MGDP - Flow rates given in millions of gallons per day
	Check Hall	...	5.83				
	Clyde	...	28.75				
	Batalie	...	11.67				
	Picard	...	13.75				
	Perdu Temps	...	4.75				
	Stuarts	...	2.25				
	Jack	...	1.25				
	Roseau	...	1.50				
	(See also Table VI)						

TABLE V (Cont'd)

SELECTED DATA ON HYDRAULICS/HYDROPOWER

Country	Major Rivers			Rainfall			Remarks
	Name	Length (km)	Flow Rate	No. of Measuring Sites	Mean Annual Low (mm)	Mean Annual High (mm)	
Guyana	Essequibo	966	...	...	1600	3556	Data given for 1978
	Berbice	644	...				
	Demerara	322	...				
	Cuyuni	483	...				
	Mazaruni	107	...				
Haiti	Artibonite (See also Table VI)	...	...	...	...	...	
Jamaica	Plantain Garden	34	...	300	762	7620	Flow rates given in millions of gallons/year
	Black River	56	253.5				
	Yallahs	37	20.1				
	Wag Water	45	4.9				
	Rio Cobre	49	86.0				
	Rio Minho	81	78.5				
	Great River	44	122.9				
	Carbaritta	36	14.7				
	Rio Grande	36	237.2				
	Martha Brae	31	123.5				
Montserrat	Belham	24	...	4	965	1778	There are no large rivers but in the peak wet season flow is high. No records of flow rate
	Bottomless Ghant	19					
	Farms	32					
	Ghant Mafraimey	27					
Netherlands Antilles	None	-	-	...	208	1111	Period 1905 through 1978

TABLE V (Cont'd)

SELECTED DATA ON HYDRAULICS/HYDROPOWER

Country	Major Rivers			Rainfall			Remarks
	Name	Length (km)	Flow Rate	No. of Measuring Sites	Mean Annual Low (mm)	Mean Annual High (mm)	
St. Kitts-Nevis	None	-	-	...	889	1168	Available data for 1972 to 1976
St. Lucia	...	-	-	...	1422	2667	Data available for 1965 to 1976
St. Vincent	South River	...	...	...	1651	2870	Data available for 1965 to 1976
Suriname	Commerwijne Corantyne Nickerie Coppename (See also Table VI)	32.1 80.5 96.6 64.4	... ...	...	1639	2280	Data given for 1975
Trinidad and Tobago	Ortoire Caroni Oropouche	... 45.0 ...	... ...	...	1626	2235	Data available for 1965 to 1974

Source: Data supplied CEPAL.

TABLE VI

HYDRO POWER/HYDRAULICS

Country	Potential Hydro Power Sites: Location	Potential Hydro Power Sites: Capacity ('000 kW)	Existing Hydro Power Sites: Location	Existing Hydro Power Sites: Installed Capacity '000 kW (1978)	Inaug-uration Date	Hydro Electricity Generation Mill. kWh (1978)	Remarks
Belize	Macal River	...					
	Rio On		None	...	...	...	Pilot project in preparation for Rio On site and Belize River. UNDP project to evaluate micro-hydro schemes *inter alia* inaugurated in 1980
Dominica	Boeri River	1.8	Roseau River	3.0	...	14	Data given for 1978
	Rivière Blanche	2.2					
	Macoucheri River	3.5					
	Layou River	8.2					
Haiti	Peligre	47.1					
	Pichon	7.0					
	Artibonete	39.0	Peligre (3)	47	...	221	Data given for 1978
	Saut Mathurine	5.0					
	Onde Verte	4.0					
	Jacie	4.0					
	Saut du Baril	4.0					
	Trois Rivières	4.0					
	Voldrogue	3.0					
	Grand Anese	3.0					
	Grand Rivière du Nord	3.0					
	Rivière Grise	3.0					
	Others	19.6					

TABLE VI (Continued)

	Potential Hydro Power Sites		Existing Hydro Power Sites		Inaug-uration Date	Hydro Electricity Generation Mill. kWh (1978)	Remarks
	Location	Capacity ('000 kW)	Location	Installed Capacity '000 kW (1978)			
Guyana	N.W. Coastal Area Cuyuni Mazaruni Potaro N.E. Coastal Area New Essequibo	7607	Potaro River, at Tumatumari	2.0	...	...	Hydroelectric power potential great, 15 potential sites
Jamaica	Blue Mts. Western Jamaica	90-100 20	Upper White River Roaring River Lower White River Rio Bueno Maggotty (1974)	3.6 4.05 4.8 2.5 6.4 21.27	1945 1949 1952 1956 1947	120	Motor Columbus Study proposes a feasibility study of a major multi-purpose scheme for hydro electric generation and water supply located in the Blue Mountains
Dominican Republic			Tavera Valdesia	150		83	Have significant H.E. Potential. Study currently being done by SOFRELEC of France. 17 small-scale hydro schemes identified
Suriname	Corantijn Kabalebo Marovijne	3,000	Afobakka	200	1965	1,310	Feasibility of potential schemes will depend on bauxite mining and aluminium smelting developments
Grenada	Black River in the Concorde catchment area	...	-	-	-	-	A survey to assess possible micro-hydro schemes could be undertaken, once stream flow data are available. The rivers of Grenada have installed in them 2 water-wheels, the energy of which is used for grinding sugar cane and other agricultural produce.

TABLE VI (Continued)

Country	Potential Hydro Power Sites: Location	Potential Hydro Power Sites: Capacity ('000 kW)	Existing Hydro Power Sites: Location	Existing Hydro Power Sites: Installed Capacity '000 kW (1978)	Inauguration Date	Hydro Electricity Generation Mill. kWh (1978)	Remarks
St. Lucia	...	-	...	.065	1965	...	Unlikely that any significant projects can be developed, besides micro-hydro schemes
St. Vincent	South River (Downstream)		South River	2		12	More hydrological data needed before the installation of micro-hydro schemes could be considered
Cuba	...		...	46	...	80	Data given for 1978.

Source: No. 10 of References and data supplied CEPAL

TABLE VII

SOLAR ENERGY

Country	Avg. Hours of Sunshine per day Min/Max	Max. Possible Hours per day	Average Daily Insolation No. Location	Min. (kWh per m^2)	Max. (kWh per m^2)	Remarks
Jamaica	6.1/8.2 (6 locations)	11.9 (June 1975)	4	4.54	6.40	Gunn-Bellani instruments used (1974-1975)
Haiti	8.5/9.7 (One location - 18m. elevation - Avg. of 7 years data)	12.0	1	4.28	6.42	(Period 1963-1966) using the Eppley pyranometer
Dominican Republic	...	...	...	...	....	
Cuba	...	...	...	...	...	
Barbados	7.3/9.4	11.5 (June 1975)	2	...	7.00 (in best conditions)	
Guyana (1976)	3.6/8.9	10.7	10	3.65	5.60	Indications are that the intermediate and southern savannahs get more sunshine and solar radiation
Belize	4.9/9.1	13.25	1	...	...	Data given is the average during the period 1973-1978 at Belmopan
Suriname	...	...	...	...	...	
Antigua	8.0/9.1	10.2 (June 1971)	1	...	...	Data available for 1968-1973 for average hours of sunshine per day
Bahamas (1976)	3.9/6.8	...	1	4.4	6.7	Solar radiation is used in the production of salt. Production is over 1.2 mill. tons per annum. Data are averaged over 1970 to 1972 for April, the month with the greatest mean insolation.

TABLE VII (Continued)

SOLAR ENERGY

Country	Avg. Hours of Sunshine per day Min/Max	Max. Possible Hours per day	Location Daily Insolation No. Location	Min. kWh per m^2	Max. kWh per m^2	Remarks
Grenada	5.0/7.2	10.0 (June 1975)	1	...	...	Sunshine data for Grenada are sparse
St. Lucia	6.43/9.08	12.1	3	...	...	Data given are averages over a period 1968-1978. Max. possible hours calculated on the average duration of the shortest and longest days per year
Dominica	5.7/9.3	11.6 (June 1975)	1	...	...	Period January-December 1978
St. Kitts-Nevis Anguilla (1976)	8.9/10.4	9.9	1	...	...	
Trinidad and Tobago	6.4/9.1	11.1	1	3.22	5.57	Data given for June 1975
Montserrat	...	...	...	...	...	
St. Vincent	...	...	...	...	...	

Source: Data supplied CEPAL and No.16 of References

TABLE VIII

WIND VELOCITIES

Country	Average Velocities (km/h) (Specify period)			Remarks
	Locations	Min.	Max.	
Antigua	1	8.8* (Oct'74)	17.1* (Jan'74)	Antigua appears in a very favourable position for the utilization of wind energy
Bahamas (1976)	3	6.7*	32.0	
Barbados (1974)	1	5.5*	9.0*	
Belize	1	...	...	
Cuba	...	...	...	
Dominica	1	11.8	30	
Dominican Republic	...	...	...	
Grenada	...	(mean)11.5*	...	Records on wind regime all non-existent
Guyana	1	4.6* (July'74)	7.4* (Jan + Feb'74)	Wind speeds in Guyana are generally lower than in the other Caribbean countries
Haiti (1965/68)	5	4.09	10.6	Min. 0.5m above ground Max. 45 m " "
	1	5.5	7.5	At 2m. " "
" (1954)	6	4.3	16.1	Heights unspecified
Jamaica (1974)	10	0.97	6.34	Planned Wind Profile Survey East + South Jamaica, 1977-78
Montserrat	...	...	...	
St. Kitts - Nevis-Anguilla (1974)	1	10.7	11.5	
St. Lucia	2	13	22	Data averaged over period 1973 - 1978, during the period 0700 hrs to 2000 hours.
	...	19	26	Minimum occurs in Sept. and maximum in June for both locations.
St. Vincent	...	...	...	
Suriname	...	...	...	
Trinidad and Tobago (1974)	1	3.7*	7.6*	

*: Knots

Sources: Data supplied CEPAL

TABLE IX

GEOTHERMAL ENERGY

Country	Indications	Temperature °C Min/Max	Min/Max Flow	Remarks
Antigua	Preliminary exploration necessary to evaluate geothermal potential			
Bahamas	Not applicable. No indications			
Barbados	No indications - no hot springs			
Belize	Preliminary exploration necessary to evaluate geothermal potential			
Cuba	...	...	...	
Dominica	Geothermal potential good			Surface manifestation extensive. Further exploration is necessary
Dominican Republic	...	...	...	Some potential apparently exists. Study needed
Grenada	No active volcanoes. Two dormant volcanoes, Grande Etang and Lake Antoine. Few hot springs			Need for more detailed examination on hot springs to determine their geothermal potential
Guyana	Preliminary exploration necessary to evaluate geothermal potential			
Haiti	At least 16 identified	48.40 max.	Max - 50 l/min	

TABLE IX (Cont'd)

GEOTHERMAL ENERGY

Country	Indications	Temperature °C Min/Max	Min/Max Flow	Remarks
Jamaica	7 hot springs identified, none fully studied; potential appears low	55 max	26/2000 (US gal/min)	Study of energy potential - Wag Water trough in Blue Mountains - should have begun mid-1977
Montserrat	Potential exists			Field studies undertaken to evaluate water circulation pattern
St. Kitts-Nevis	No information to date			
St. Lucia	Potential energy capacity of 10,000 kW			Several holes have been drilled; seven wells during 1974-1976 as part of exploration programme
St. Vincent	Volcanic activity			Preliminary exploration and geo-thermal surveys necessary
Suriname	Preliminary exploration necessary to evaluate geothermal potential			

Source: Data supplied CEPAL.

TABLE X

NUCLEAR ENERGY

Country	Indication of Uranium Ores or other Signs of Radio-activity	Temperature of Water °C	Flow Rate	Remarks
Jamaica	Notably in four mineral springs located in southern half of Guava Springs	High 55°C (Guava Spring, Portland)	Max - 2000 US gall	Analysis of Radioactive mineral in water samples show possible potential
Trinidad + Tobago	Proper geological survey for nuclear indications is yet to be undertaken			
Haiti	No definitive information is available on the nuclear fuel potential of Haiti. Indications are unfavourable.			
Cuba	Geological surveys to be done to assess potential			Cuba's first nuclear reactor is now under construction and will be completed in 1981. Two nuclear plants to be located at CIENFUEGOS
Guyana	Possible Uranium deposits in the Pakaraima Mountain range			Quality and extent of deposits not known

Note: Data are not available on this field for other CDCC countries

Source: 2, 3, 6, 12 of Reference and data supplied CEPAL

TABLE XI

PRODUCTION OF FUELWOOD AND CHARCOAL, 1978

Country	Fuelwood (Mill. m^3)	Charcoal (Mill. MT.)
Belize	0.076	...
Cuba	1.500	...
Dominican Republic	1.737	...
Guyana	0.016	...
Haiti	3.488	...
Jamaica	0.001	...
Suriname	0.018	...
Trinidad and Tobago	0.010	...

N.B.: Data are United Nations Estimates.

Source: No. 10 of List of References.

TABLE XII

SELECTED DATA ON BAGASSE, 1978

Country	Actual/Estimated Consumption ('000 MT)	Sugar Production ('000 MT)	Estimated Bagasse Yield ('000 MT)**	REMARKS
Antigua	...	5*	8*	Plans to re-activate the sugar industry in the next two years.
Barbados	160	100	155	(135,000 MT. used as (fuel in all sugar (factories.
Bahamas	...	...	...	
Belize	...	115.3	173	Bagasse used as fuel in the sugar factories
Cuba	...	6,485	9,728	Bagasse supplies 35% of gross energy consumption. Experiments are underway, for using bagasse to make paper.
Dominican Republic	...	1,361	2,042	
Grenada	...	1	1	Used to fire boilers of sugar factories in combination with waste wood.
Guyana	...	330	495	
Haiti	...	48*	72*	
Jamaica	446*	305	458	Considerable amount of bagasse is used as fuel in sugar industry, and there is competing demand for use as fibre-board.
St. Kitts, Nevis, Anguilla	...	43*	65*	
St. Lucia	...	...	...	Last known production in 1963.
St. Vincent	...	...	...	Last known production in 1962.
Suriname	...	6*	10*	
Trinidad and Tobago	...	147	220.5	

* : Data given for 1977. **: Relate only to bagasse from sugar production.

Source: - Data supplied CEPAL.

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