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I - The Energy Situation in Brazil

With a population of 121 million in 1980 and a GDP of US$ 230 billion, Brazil is the eighth economy in the Western World. Its production of steel (16 million tons), cement (28 million tons), motor vehicles (1.2 million units), cereals (52 million tons) places the country in an important position within the western community. The rythm of future Brazilian development, however, broadly depends, today, on an adequate solution to the energy problem. The profile of energy production and consumption in Brazil was shaped in the last three decades, when oil became the basis of the energy balance of the country; oil prices in the international market were so low that all physically viable alternatives for equivalent hydrocarbon liquid fuels became economically unattractive. In fact, oil consumption which represented about 28% of primary energy used in the early fifties (1952) went up to 44% in 1973. In absolute terms, oil consumption increased from 6.7 million tons in 1952 to 33.7 million in 1973. The average yearly growth rate in the period 1952/1973 was 8.1%; the last five years of the period, however, presented a rate slightly higher than 11%. The momentum was such that despite the so-called oil crisis and the escalation of prices since then, Brazil's oil consumption went up, in absolute terms, to 47.9 million tons in 1979, representing 40.7% of the total consumption of of primary energy, and of which 85% are imported.

It is noteworthy that another energy source available in the country, namely hydro-power, was also largely used and its contribution to primary energy consumptioı in the form of electricity went up from 11.2% of the total (2.7 million TPE) (1) in 1952 to 21.9% (16.7 million TPE) in 1973, and 28.3% (33.3 million on TPE) in 1979.

It can thus be seen that, together, oil and hydro-power went up from 39.0% in 1952 to 69% of total primary energy consumption in 1979.

The evolution of the structure of the energy consumption in the country is shown in the following table:

Primary Energy Consumption
(thousand TPE and percentages)

YEARS	1952		1979	
	TPE	%	TPE	%
Oil	6,679	28.0	47,975	40.7
Natural gas	1	0.0	498	0.4
Mineral Coal	1,476	6.1	5,123	4.3
Hydro power	2,663	11.2	33,379	28.3
Ethanol	-	0.0	1,876	1.6
Firewood	11,921	49.9	20,469	17.4
Charcoal	641	2.7	2,976	2.6
Sugar Cane Bagasse	509	2.1	5,489	4.7
TOAL	23,890	100.0	117,785	100.0

Source: Ministry of Mines and Energy and "National Energy Balance, 1980".

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(1) TPE = tons of petroleum equivalent.

From the above it can be noted that energy consumption went up at a fast pace, the overall yearly rate (1952/1979) was slightly above 6%. In per capita terms, consumption went from an extremely low level of 0.43 TPE/ inhabitant in 1952 to a still low level of 0.98 TPE/inhabitant in 1979, even taking into account the tropical situation of the country and the consequent absence of heating requirements in most of the country.

There is no doubt that the use of oil-based liquid fuels, instead of available domestic alternatives, had technological and economic advantages, at the time it was implanted and during the period when it expanded rapidly. Like all other oil importing countries, Brazil was not historically, technologically and economically in a position to undertake the immense research effort needed to bring about acceptable alternatives. There was, moreover, virtually no likelihood that any alternative fuels would be produced at costs comparable to those of oil extration in the main exporting areas. Besides, at the then prevailing prices, there were no macro-economic or balance of payments incentives to undertake this effort.

However, all factors mentioned above, especially those of a political, economic and technological nature, have undergone irreversible changes. Since the oil-price escalation, the production of liquid hydrocarbon fuels based upon biomass has begun to be economically viable and its technology

technology is virtually within the reach of any country located in the tropical or sub-tropical belts. The gasification of coal and the production of liquid and gaseous fuels from oil bearing shales and tar sands are becoming economically competitive. The new price structure for oil heralds a new economic universe with characteristics very distinct from those that prevailed until the begining of the 70's.

As a result, a pattern of efficient energy production and consumption, essentially based on available national resources, is being implanted. Such programmes for the substitution of imported primary energy sources, although geared to solving the energy problems of the country in the short and medium terms, present perfectly viable solutions for other countries, both developed and developing, and hold perhaps the key to the global solution of the present liquid fuels crisis.

In the case of Brazil, the country's self-sufficiency in energy is hindered only by the lack of financial resources, since there are no possibilities of channeling the amounts required for the immediate mobilization of the country's energy resources. In fact, probably, if the country counted on substantial availability of capital, its immense domestic potential would have already been mobilized and the time span for utilization would only be measured in relation to the beginning of projects' operation, as shown

shown below:

- Brazil has the second world hydropower potential - 213,000 MW - with only 11% of its capacity in operation;

- it has the fifth world's uranium reserve - 236,000 tons of U_3O_8 and one of the largest of oil shale - 672 million m3;

- the reserves of coal - 22 billion tons - are considerable and pratically not exploited;

- the country has privileged conditions for biomass production with an 8,5 million km2 of mostly tropical land mass, a range of sunlight that varies from 700 to 750 W/m2, the annual incidence of sun rays being approximately 2,300 hours; precipitation on the other hand ranges from a minimum of 300 mm in a relatively small area in the Northeast to more than 2,500 mm in the huge areas of equatorial forests;

- and, in addition, approximately 3,168,000 km2 of the land surface (i.e., 8,456,050 km2) and 800,000 km2 of the continental platform (in approximately 8,000 km of coast) are sedimentary basins, one of the characteristics, although not sufficient by itself, for the concurrence of petroleum.

II - Strategy of Action and Sectoral Programmes

Brazil's present energy policies are based on the premises of acquiring energy self-sufficiency in the medium term, preceded by a progressively decreasing dependence on the short term.

In the current transition period, there is need to seek sources, renewable or not, that would replace by-products of imported oil; in a second stage, in the future, self-sufficiency based exclusively in renewable sources will

will be sought.

Once self-sufficiency has been defined as the main policy component, the basic guidelines for the Brazilian action in the energy field are:

(1) increase of domestic oil production and of energy sources capable of replacing by-products of imported oil;

(2) energy conservation and substitution of domestic sources for by-products of imported oil;

(3) generation of advanced technologies in research, production and utilization of conventional and non-conventional sources and forms of energy, as well as transfer of technologies that are of interest to the country.

The Brazilian Energy Model, taking into account a consumption estimate of 1,700,000 barrels of petroleum equivalent per day (bpe/d.) in 1985, set the following production targets for that same year: 170,000 bpe/d. of alcohol, 110,000 bpe/d. of mineral coal, 120,000 bpe/d. of charcoal, 25,000 bpe/d of oil shale, 15,000 bpe/d of other alternative sources, plus savings, through energy conservation of 200,000 bpe/d..

Therefore, while the consumption of imported energy in the 1969/79 period increased at an annual average rate of 11.4% (of which 11.5% for petroleum and 9.3% for mineral coal), it already significantly decreased in the last quinquenium (1975/1979) of that period to 7.7%; it is now

now projected to decrease, in the 1980/85 period, at an annual average rate of approximately 9.0%, resulting in a reduction in foreign dependence (consumption of primary energy) from 37.1% in 1979 to approximately 16% in 1985.

In this period, the transition in renewable sources of energy is envisaged from a profile where its participation in the total primary consumption of energy in 1979 (117,785 TPE) was of 54.6% to a percentage of 65.3% in 1985, within an energy primary consumption estimated at 173,931 TPE.

For this purpose, in the period 1979/1985 the following annual rates of consumption increase are estimated: hydropower 12%; charcoal 20.5%, sugar bagasse 9.9% and alcohol 24.7%. It should be noted that in the period 1969/1979 the annual rates of increase were of 13.4% for hydropower, 9.6% for charcoal, 8.1% for sugar bagasse and 52.8% for alcohol, without taking fuelwood into account.

Among the non renewable sources, efforts for the development of production of domestic oil, mineral coal and oil shale must be emphasized.

An intense and priority action for the prospection of oil in the national territory already allows for the programming of a production increase from 198,500 barrels/day in 1980 to 500,000 in 1985.

This programme has required a significant

significant intensification of work in surface geology, in geophysics, in pioneer drilling, as well as large efforts in the evaluation of results and in the development of newly identified producing areas. Drilling work, for instance, has been stepped up rapidly, increasing from 238,000 meters in 1973 to an estimated 811,000 meters in 1980, a great part of the latter representing "off-shore" and even deep water drilling.

Because of the similitude of the final product with petroleum, mention must also be made of oil bearing shales, of which Brazil has reserves equivalent to 4,200 million barrels (recoverable oil). After completion of pilot work (Pilot Plant in Irati), a production target of 25,000 barrels a day has been set for 1985, at production costs well below FOB costs of imported oil. In a second stage, the project is expected to yield 50,000 barrels a day.

Mineral coal is another important component of the strategy of substitution of imported oil. Its reserves represent 84.75% of Brazil's fossil fuels and it will have a significant role to play in the change of the structure of primary energy consumption, mostly through its utilization as a fuel oil substitute.

Its participation in the total consumption of primary energy will increase from 4.3% in 1979 to 8.7% in 1985, and, in absolute terms, from 5,0 million tons to to 19, 7 million tons, respectively.

Technological alternatives for the utilization of Brazilian coal, with high ash content, are being developed, such as direct burning, mixture with fuel-oil and gasification. Technical-economic analyses are being made in order to establish the most adequate solution in each case.

The modification of the structure of fuel- oil consumption is being planned with a view to replacing it by coal in the following sectors: thermoelectric generation, steel making, cement, ceramics and glass, paper and cellulose, food and beverages and rail and sea transportation.

It is estimated that by 1985 about 29% of the total fuel-oil demand will be met by domestic coal. Considerable investments will be necessary in mining and transportation (railways and ports) and gasification plants will have to be installed. Productivity will have to be increased through scientific and technological research in the major types of national coal, both for energetic and metallurgical purposes.

Finally, in the area of energy conservation a great effort is being made to discourage superfluous, inefficient or predatory use of energy. For this purpose, a whole set of governmental measures and policies have been

been adopted, inter alia, the bringing about of conservation conscience in consumer's campaings for the rational use of all types of fuels, price policies that aim at cutting down the use of imported primary energy and adequate planning of mass transportation systems, including electrification of railways and subway construction, among others.

In the following pages, the main programmes on new and renewable sources of energy being developed in Brazil are described in more detail.

2.1 The National Hydroelectric Programme

Hydropower energy is abundant and can be used for generation of large blocks of electric energy. The basic foundation for this energy of hydraulic origin is the significant hydric potential existing in Brazil, estimated in 1979 at 213,000 megawatts, with a firm energy average of 106,500 MW, equal to 933,000 annual GWh, i.e., equivalent to 5.6 million oil barrels per day. It is noteworthy that approximately half of this potential is located in the Southeast, South and Northeast regions, near the main consuming centers.

More than 90% of the total hydroelectric potential of the country has already been surveyed and analysed. The results are rather promising, mainly in the Araguaia-Tocantins basin located in the Amazon region. The studies which have been undertaken represent a fundamental step in the

the formulation of the Brazilian Energy Policy and in the decisions on the amount of hydroelectric power that will be part of the total energy production. There are also therefore direct implications for important segments of both Brazilian technology and national economy, through engineering concerns and industrial equipment and construction enterprises.

The "Plano de Atendimento aos Requisitos de Energia Elétrica ate 1995" (Plan for the Satisfaction of Hydropower Energy Needs Until 1995) was developed in 1979 in order to take into account the priority which was attributed to this sector in the national energy policy. It indicates the main measures recommended for the steady expansion of the electric energy sector, whose generating capacity will have to be tripled, i.e., from the 25,200 MW existing in the end of 1978 to 71,000 MW in 1995.

A growth of 12.7% per year, between 1979 and 1985 is foreseen for the electric energy market; and of 8.2% from 1985 to 1990 and 7.4% from 1990 to 1995. The construction schedule presently in execution guarantees an increase of 25,900 MW, of which 20,400 MW from hydroelectric, 3,100 MW from nuclear and 2,400 MW from conventional thermoelectric plants.

An overall increase of 30,000 MW is predicted for the 1991/1995 period and the "Plan 95" also foresees the

the possible total elimination from 1985 onwards of the inter-connected systems of electric energy generation based on imported oil, by determining all measures to be adopted for the expansion of the electric energy sector in a way that facilitates meeting fully the projected demand in terms of the development of the economy as a whole.

In this context, large efforts are being undertaken including building of large scale hydroelectric plants such as Itaipu with 12,600 MW (joint enterprise Brazil-Paraguay) and Tucuruí with 3,960 MW (fully Brazilian), and, in addition, the interconnection of the electric systems of the North and Northeast regions, through a tansmission line of 500 kW, that will allow the replacement of large blocks of thermoelectric energy, based on oil by-products, by energy of hydraulic origin, as well as allowing for the development of important developing centers, such as the Carajás project and the aluminum production projects in the States of Pará and Maranhão.

In the present decade, average annual investments in the hydroelectric sector will amount to approximately US$ 7 billion. In 1979, about 10% of fixed capital formation in Brazil occurred in this fundamental sector. In 1985, the participation of hydroelectricity in total primary energy

energy consumption will go up to 35% (it was 28.3% in 1979) and is expected to reach 40% by the end of the century.

The efforts to develop this programme derive from the fact that the Southeast, with 40% of the country's population and most of its industry, holds only 7% of the national hydroelectric potential, while the Northern region, with only 4% of the population, holds 46% of the total potential. In fact, the most economically viable hydroelectric potentialities that are close to the main consuming centers are either already in use or in the process of utilization in the near future.

The satisfaction of consumption at the rates envisaged in the Brazilian market will also require long-distance power transmission in high and/or extra-high tension as, for example, from the North to the Southeast, in the Southeast and from the North to the Northeast, in order to establish the interconnection between the Amazon region, where the country's largest hydric reserves lie, and the area where the main Brazilian industrial park is located. This will constitute an effective instrument for improvement and reliability of supply and also for the complete elimination, in the future, of electric energy generated from oil.

Brazil already commands the whole range of technological know-how in the areas of planning, project engineering, cost evaluation and budgeting construction and operation of hydroelectric plants, only remaining at present

present a small dependence on technologies for plant operation Control Systems.

The nationalization rate in equipment manufacturing has already reached 90%, and it is to be emphasized that the domestic industry is already capable of filling orders for the manufacturing of turbines of the size of those that will be used in Itaipú (700 MW each).

2.2 - The National Alcohol Programme (PRO-ÁLCOOL)

Under existing Brazilian technological, economic and social conditions, ethanol was, among many other viable alternatives, the one that presented the best potential for rapid development and immediate and significant impact on the liquid fuels market.

The National Alcohol Programme was launched, at the end of 1975, with the aim of increasing national alcohol production for fuel and industrial purposes and with a view to replacing petroleum products.

The initial target of the Programme was the production of 3.0 billion litres of alcohol, by 1980, with the objective of replacing part of the gasoline consumed in the country, by means of adding alcohol to gasoline, up to the optimum technical limit of 20%. This proportion represents the maximum utilization of ethanol that does not require significant alterations in Otto cycle engines and

and assures an identical performance to that obtained with pure gasoline.

As a complement to these measures, research and development activities were started aiming at increasing productivity in all the stages of alchohol production and at designing engines to be propelled exclusively by alcohol. These targets were fully met and, in 1979, conversion of Otto cycle engines to the use of pure alchohol (hydrated) was started and national designs of new engines for the same fuel were approved. By 1980, the gasoline and alcohol blend was currently used in most regions of the country, where alcohol production was possible and compatible with transportation and consumption. Furthermore, the process of production of alcohol was considerably improved.

In view of the successful completion of this first phase of the Programme - 1975/1979 - new and more ambitious targets were established. The new production target for 1985 is 10.7 billion litres of alcohol and 16,0 billion litres for 1988. The purpose will be not only to replace gasoline but also inputs for the petrochemical industry (about 1,5 billion litres of alcohol will be reserved for the petrochemical industry in 1985). The ethanol production figures for 1985 will be equivalent to 170,000 barrels of oil/day and those for 1988 will correspond to 254,000 barrels/day.

The action of Government agencies responsible for the co-ordination of the Programme, the governmental incentives given to it and the immediate response of the business sector to the Government's initiatives have made it possible that "PRO-ÁLCOOL's" production targets and objectives be met. Thus, the Programme today encompasses a large number of integrated activities in the areas of production of agricultural raw materials, production, distribution and utilization of alcohol, as well as research and technological development. US$ 5 billion have already been assigned to the development of the Programme until 1985.

In 1980, about 200,000 new cars were produced with engines specially designed for the exclusive use of hydrated alcohol and about 60,000 car engines were adapted to use alcohol instead of gasoline. For 1981, the production of a total of 300,000 cars with ethanol powered engines has been programmed as well as the adaptation of 90,000 car engines. For 1982, about 350,000 ethanol powered cars will be put into the market, simultaneously with the conversion of 100,000 engines, so that, by the end of that year, about 1,1 million cars should be rolling on this new, renewable and home-produced fuel.

The National Alcohol Programme is, however, much more than an energy solution developed with genuinely national technology and suited to the natural soil and climate conditions in Brazil. Important socio-economic elements are incorporated in it so that it represents an important instrument

instrument for increased employment, for the reduction of the excessively rapid movement of population to urban centers and for the redistribution of income. The target of production for 1988 should create 800,000 direct jobs and a much larger number of indirect ones, mostly in rural areas. So far, well over 50,000 new direct jobs are estimated to have been created by the Programme.

2.3 The National Vegetable Oil Programme (PRO-ÓLEO)

The possibility of using vegetable oil as a substitute for diesel oil has proved to be one of the most effective measures to meet the demand, in the medium terms, generated by diesel engines and for this very reason it has become the cornerstone for the establishment of the National Vegetable Oils Programme in the substitution of diesel oil.

Oil producing plants that potentially integrate the diesel oil substitution programme can be of annual or perennial cultivation. At the outset the programme would depend on annual oil producing plants that can give immediate response but that enjoy some disadvantage in terms of productivity in area. In the medium term, the goals of the programme would be met with perennial plants, which in most cases represent considerable gains in productivity, although the production cycle begins only 5 to 8 years after the start of cultivation.

cultivation.

Preliminary surveys show that Brazil has sufficient suitable areas, in several regions, for large scale growing of oil producing plants either of annual or perennial type.

This programme methodology makes clear the option for adapting the oil to the engine, instead of the engine to the oil, in a progressive and constant pace. The programme would be initiated through addition of vegetable oil to diesel up to a ratio that does not affect the engine's performance; in another stage, diesel oil would be replaced by modified vegetable oil, without mixture. This change aims at turning vegetable oil into a product of physico-chemical characteristics very similar to those of diesel oil.

Many processes for the alteration of vegetable oils, in order for them to have the above mentioned characteristics are known:

- alcoholic transesterification, in which the approved process as the one using methanol in the alcoholisis;
- thermal cracking of the saponifiable material contained in vegetable oils;
- catalytic cracking of vegetable oils in rough form.

All these methods are currently being the object of studies and analyses by the Governmental agencies that run the programme.

As a by-product of the vegetable oil programme there will be a large surplus of protein rich foodstuffs that

that have a high nutritional value and great national and international demand.

It is expected that by 1985 Brazil will have 1.9 million m3 of vegetable oils available for fuel purposes, without prejudice to the production of foodstuffs. Meanwhile, the introduction of perennial oleaginous plants will permit in 1990 the production of about 9.7 million m3 of vegetable oils to replace diesel.

2.4 The National Fuelwood and Charcoal Programme

Fuelwood is one of the most "renewable" sources of energy used by man. The main advantage that in principle fuelwood presents over other energy sources is the universality of its distribution. This advantage, added to the simplicity of its use even with rudimentary techniques, offsets its greatest disadvantage, that of its low calorific content. As a result, it is only natural that fuelwood can not endure long transportation and that its consumption is restricted to the vicinity of production zones. Whenever there is need for transportation, fuelwood becomes charcoal.

Charcoal comes from the pyrolysis or distillation of wood and is composed of a solid fraction, as well as volatile and condensable fractions. Its content is almost free of sulfur and very low in ash levels and makes it an excellent input for the steel industry, without mentioning

mentioning its high calorific power.

There are presently well developed technologies for converting fuelwood into charcoal, such as that which uses retort, where fuelwood is carbonized in the absence of oxygen, generating high yields in terms of fuelwood/ charcoal and making possible the use of volatile and condensable fractions.

In the case of wood (forest products) the technology for the production of ethanol is being used in order to promote the setting up of medium sized industrial plants that will transform the cellulose of forest products into ethanol, through acid hydrolisis, followed by fermentation and distillation. This process will yield not only ethanol but a series of economically significant by-products, both in economic and in energy terms, such as lignin, coke, furfural and methane gas.

In Brazil, methanol can be produced from domestic and renewable raw materials, with high rates of home-made equipment and technology and, what is most important, at attractive costs, even compared to petroleum-based product costs. Pilot work is being undertaken in the area of methanol production from wood.

The continental size of Brazil with a large forest cover, either natural or planted, generates a considerable energy potential from fuelwood. Antoher important factor in appraising this potential is the tropical and ecuatorial

ecuatorial nature of Brazilian forests, which yield a much more rapid and lavish growth than in temperate regions.

Fuelwood and charcoal are renewable sources of energy that in Brazil are also programmed to replace fuel oil derived from petroleum in regions where it would not be economically viable to use coal due to the great distances from the consuming centers. These regions are the North, the Northeast and the Centerwest. Governmental measures of a restrictive nature in relation to fuel oil supply to industries and other users are already encouraging the operation of the Natioanl Fuelwood and Charcoal Programme.

The supply of wood in Brazil in 1980 was 1,407,462,000 tons from natural forests, and 31,087,000 tons from cultivated forests, amounting in total to 1,438,549,000 tons. Fuel oil consumption, for the same period, was of 18,585,000 tons, a figure equivalent to 59,456,200 tons of wood, thus placing emphasis in the domestic potentiality for the replacement of fuel oil by fuelwood or charcoal.

2.5 The National Oil Shale Programme

As indicated above, Brazil has very large reserves of oil bearing shales (672 million m3), the second largest in the world.

A great effort of research and technological development in this sector has already been made. These

These activities are now concentrated on the largest shale reserves of the country - the Irati area - that spreads through the South region of Brazil, reaching some parts of the Centerwest region. Since the conclusion of laboratory and pilot work (in Tremembé - State of São Paulo) a prototype pilot plant has been built in São Mateus do Sul, Paraná State, using the PETROSIX process, fully developed in Brazil. This plant has been running for some years, having already fulfilled its basic purposes, i. e., to demonstrate the viability of the relevant Brazilian developed technology (PETROSIX process) and gather information for the basic project of a large scale industrial plant, which will also be located in São Mateus do Sul and should start production in 1985, with an initial capacity of 25,000 barrels of oil per day, together with marketable by-products. The basic engineering projects were concluded in May 1980 and are entirely Brazilian. The equipment and material to be used in the plant will also be 90% national.

It would be interesting, however, if an interchange of information and technical co-operation programmes could be developed with other countries working in oil shale development. Brazil would be in a position to offer technological information both in the area of mining and of industrial processing and would be interested in financial support for further development of its projects.

projects.

2.6 OTHER PROGRAMMES

A certain number of renewable sources of energy of general interest may find specific applications in the country and, as such, are receiving special attention. A brief description of specific uses of such sources, as well as of the problems that are being encountered for their use follows:

2.6.1 B i o g a s

The biogas potential in terms only of manure as raw material is estimated in $15,310^3$ TPE/yearly (taking into account the utilization of 15 kg of manure/animal/day and based on the 1974 cattle herd).

Taking this into account, the Government decided to allocate financial resources for the development of a programme aiming at the utilization of this organic source of energy, especially in rural areas. Bio-digesters will be installed in those areas for the generation of biogas and bio-fertilizers. The latter are important not only as agricultural inputs but also as substitute to imported chemical fertilizers. Bio-digesters in Brazil will be destined to meet energy needs of small and medium rural properties, with the objective of cutting down the use of petroleum-based products.

products.

Bio-digesters of Indian and Chinese models are presently used in Brazil. There are also some domestic models in use.

Other high potential biogas sources can be explored. Taking sugar cane as an example, the industrialized by-products and even the leaves that are left in the field can be used in bio-digesters that, apart from gas production for industrial use, avert water polution and organic substance recycling.

The utilization of remnants of tanneries and cold storage plants in bio-digesters is already in practice.

Technology for bio-digester utilization of "Aguapé" (variety of water lily or aquatic plants) is also in existence. Its large scale use presents however a few problems related mainly to the transportation of the green mass, which requires studies and proper solutions.

Another possibility that is being explored for biogas production is the sanitarian garbage fillings in the great urban centers as well as other organic industrial residues.

In the present stage of the use of biogas, it is necessary to develop energetic biogas systems that can promote the participation of this input in the energy consumption, mainly in sectors where imported energy is dominant, such as in the industrial sector.

sector.

The identification of industries that use imported energy and eliminate organic residues would allow their use in bio-digesters that would partially supply the energy needs of the industrial process; in other words, the time is not only suitable for the study of anaerobic bio-digestion, but also appropriate for determining benefits that the process will bring for energy conservation.

2.6.2 Solar Energy

Brazil is in a position both technologically and industrially to produce solar heaters for domestic and for industrial purposes, within a range of temperatures reaching 80° C. About 30 different types of heaters are already in the market in Brazil.

There are additionally other interesting possibilities in this field whose utilization depends on further domestic research and technological development or, alternatively, on external technological contributions. In the short term, it would be interesting to use solar energy, in Brazil, for:

a) the production of ice through absortion systems;

b) air conditioning;

c) the generation of low pressure steam for

for industrial uses;

d) the generation of mechanical power up to 100 kW;

e) water pumping;

f) residential use with a view to energy conservation.

In the medium and in the long run, Brazil is interested in the development and production of:

a) parabolic collectors for utilization in processes that require temperatures above 100° C;

b) solar cells from monocrystalline silicium or other semi-conductor material.

In all the above mentioned sectors, Brazil will have to make substantial investments and entertain technical interchanges. With this end in view, Brazil welcomes bilateral agreements with other countries that are also interested in research and development in the field of solar energy.

2.6.3 Windpower

There is currently in Brazil an output of multi-sail windpower units, with a maximum of 6 kW of installed capacity, for the generation of electricity and for water pumping.

Some national research institutions and

and universities have already developed technologies for the production of small wind mills (with a vertical axis, of the Savonius type) for surface irrigation purposes, with capacity of pumping 5,000 litres/day, to a height of 10 meters.

Brazil would thus welcome the opportunity to enter into arrangements with research institutions and universities in other countries, aiming at technical interchange and co-operation in the following areas:

1 - in the short term:

a) industrial production of low power wind units (1 to 2 kW) to generate electric power for residential purposes;

b) production of wind-solar systems for dehydration and drying of food and for refrigeration;

c) the collection of data on wind power in the different regions of the country.

2 - In the medium and long term:

a) development of windpowered units in potencies above 5 kW, aiming at the integration of wind-electric systems to be run in isolation or connected to the existing electric grids;

b) development of wind-generators based upon vertical axes, with a potency of around 20 kW, for utilization in rural areas;

c) development of equipment for control, conversion and storage of electric power.

2.6.4 Ocean Energy

Brazil has a mainly tropical territory and about 8,000 km of coast. It has therefore a very significant

significant ocean energy potential, which is evidenced by the analysis of oceanographic parameters, such as thermal sources and its range, proximity of users, waves data, estuary characteristics, maritime currents and storm's periodicity. Specific programmes of research and technological development are being carried out in this area and include the exploitation of wave and tidal energy, thermal gradients (OTEC) and saline gradients for the production of electricity.

The future use of ocean energy in the country will be made possible if the necessary financial investments are available and taking also into account the technical and material resources already available in Brazil, as well as technical interchange through close co-operation with other countries. The technical and material components of an ocean physic energy exploration programme in Brazil are sufficient to permit that 80% of the equipment to be used is of national origin.

III - Scope for International Co-operation

The preceding chapters have shown that the Brazilian strategy towards the energy problem is very broad in its approach. Although primarily directed to the solution of the problems generated by oil-based liquid fuels, it encompasses the development of all other non-conventional sources which may contribute to national development and to to the optimum exploitation of its energy potential.

In what regards research, technological development and exploitation of biomass-based liquid fuels, as substitutes for petroleum by-products, the country is in an advanced position, using genuinely national technology for production and exploitation. This sector offers ample opportunities for international co-operation, especially at the South-South level.

The rich photosynthetic environment of almost al the developing countries (almost all of them situated in tropical or sub-tropical areas), the technological simplicity of the production process which has been developed, the low cost of goods and services necessary to production on an industrial scale and the simplicity of using biomass liquid fuels in the same capital equipment in which petroleum by-products are currently utilized, offer considerable possibilities for an accelerated expansion of production and utilization of such fuels. Intensified vertical and above all horizontal international co-operation in the sector will help considerably in the attainment of this goal. Brazil has encouraged such co-operation bilaterally as well as in multilateral forums.

To intensify vertical co-operation, the effective commitment of industrialized countries to the promotion of a real transfer of resources and know-how to the developing countries is mandatory. This will contribute

contribute to create and strengthen a scientific and technological infrastructure in the developing countries, taking always into account their own plans and development programmes and priorities.

The possibility of expansion in this sector on the basis of horizontal international co-operation demands the solution of difficulties such as the following:

a) at the bilateral level, co-operation among developing countries fails to expand at the desirable rate in view of the absence of resources in the volume required especially financial resources;

b) in the multilateral level, the necessary priority has not yet been given to research and technological development projects or to programmes of production and utilization of such fuels.

The strengthening of South-South co-operation in the area of biomass-based liquid fuels demands, therefore, efforts at both levels. Mobilization of international resources in sufficient volume could give great momentum to technological co-operation among oil-importing developing countries, with a tropical environment, enabling them, in the medium term, to produce alternative liquid fuels, on the basis of technology and services compatible with the reality and the existing socio-economic conditions in the developing world. In the same way, international organizations should grant priority to technical co-operation projects in the

the biomass-energy sector and give preference to the utilization, in these projects, of tested goods and services coming from developing countries already qualified in this field.

As indicated in the preceeding chapters, all the other new and renewable sources of energy are equally undergoing research and technological development, although at a much less advanced stage than that already achieved by national programmes of biomass liquid fuels, both in terms of volume of financial resources applied and in terms of research, development and incorporation into the productive sectors of the national economy. It is known, however, that industrialized countries, due to a higher availability of human, financial and technological resources, have succeeded in implementing broad research and development programmes for the different non-conventional energy sources both at national level and within ad hoc international organizations. In absolute terms, there is no doubt that the investments already made and the results obtained by industrialized countries in these non-conventional sectors (excepting biomass) surpass those achieved by developing countries.

Aware of this fact, and with a view to encouraging production and local application of all non-conventional sources of energy available in the national territory, and simultaneously with its research, technological development and training of human resources, Brazil seeks

seeks to follow developments and results obtained abroad, and favours bilateral agreements which may lead to absorbing scientific and technological knowledge in those sectors which are most suited to the national socio-economic conditions. Brazil also supports multilateral initiatives aiming at such goals which are likely to lead to an effective improvement of North-South relations in the fields of research, technological development, training of human resources and information interchange in all non-conventional energy sectors that may benefit the developing world as a whole.

It would be desirable that the United Nations Conference on New and Renewable Sources of Energy could multilateralize such efforts, through international co-operation based on an effective, realistic and equitable terms, with a view to the development and increased utilization of such sources of energy for the benefit of mankind as a whole and, especially, of the developing countries.