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# ENERGY SUSTAINABILITY IN LATIN AMERICA AND THE CARIBBEAN: THE SHARE OF RENEWABLE SOURCES

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Deutsche Gesellschaft für
Technische Zusammenarbeit (GTZ) GmbH

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# ENERGY SUSTAINABILITY IN LATIN AMERICA AND THE CARIBBEAN: THE SHARE OF RENEWABLE SOURCES

This document was prepared for the Regional Conference for Latin America and the Caribbean on Renewable Energy, to be held in Brasilia, Brazil, on 29 and 30 October 2003 under the auspices of the Economic Commission for Latin America and the Caribbean, as part of the ECLAC/GTZ project "Promotion of economic development through the integration of environmental and social policy approaches in Latin America and the Caribbean".



Deutsche Gesellschaft für
Technische Zusammenarbeit (GTZ) GmbH

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The Commission is grateful to José Goldemberg, Secretary of the Environment of the State of São Paulo, Brazil, for his methodological contribution.

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# SUMMARY

By 2010, the countries of the region are to modify their energy structure so that at least 10% of their Total Primary Energy Supply (TPES) comes from renewable sources. This target is laid down in the Latin American and Caribbean Initiative for Sustainable Development, which was introduced and adopted at the first special meeting of the Forum of Ministers of the Environment of Latin America and the Caribbean, held in Johannesburg, South Africa, in August 2002.

The aim of the Initiative is not to penalize countries whose natural conditions are less conducive to energy sustainability, but rather to bring about an increase in the share of renewable sources at the regional and global levels.

To this end, in addition to the efforts made by each country, progress could be made at the regional and subregional levels through joint activities in areas such as: (i) technology exchange; (ii) cooperation to assist isolated communities; (iii) training; (iv) integration of energy networks in order to achieve minimum targets; and (v) development of accounting methods and mechanisms for the exchange of renewable energy certificates.

The concepts of energy "renewability" and "sustainability" have been a subject of intense debate. In this document, **renewability** is defined as an attribute of the source and **sustainability**, as an attribute of the way the source is used. Accordingly, to determine the share of renewable sources in the region's TPES in 2000, it was necessary to establish uniform criteria for the countries considered, while attempting to exclude from the category of "renewable" sources the unsustainable portion of biomass energy that comes from forest resources whose extraction rate exceeds the rate of natural regeneration, giving rise to deforestation processes.

The results of this study show that the share of renewable energy varies widely from one country to another, almost irrespective of their relative levels of development and, to a lesser extent, of their non-renewable energy resource endowment. The situation of the TPES and of energy problems in countries such as Argentina, which is self-supplying and a minor exporter in terms of hydrocarbons, is very similar to that found in major exporters such as Mexico and Venezuela. Obviously, these situations, in turn, are diametrically opposed to the one in countries that import hydrocarbons. Even within the latter group, however, the situation in Haiti, Honduras and Guatemala is surprisingly different from the one in Uruguay and Costa Rica, for example.

The calculation of the TPES renewability index shows that some countries, such as Argentina and the group of Caribbean countries referred to here as subregion 1 (Barbados, Suriname, Guyana, Grenada and Trinidad and Tobago), fell short of the 10% target in 2000. Other countries need to make strenuous efforts if they are to maintain the target level set out in the Initiative. Countries in the 10%-to-20% range, such as Chile, Ecuador, Mexico and Venezuela, must take decisive action to maintain the current share of renewable energy in their TPES. A third group of countries, for which the risk is lower, consists of Bolivia, Colombia, Guatemala and Panama.

In El Salvador, Guatemala, Haiti, Honduras and Nicaragua, wood energy plays a crucial role in the TPES. While this is undoubtedly positive in terms of sustainable development, since it indicates that the use of fossil fuels is limited, it is clearly negative in terms of the dramatic impact on national forest resources and on the quality of life of the users.

Conversely, in countries where the use of biomass as an energy source is almost negligible, such as Argentina, Ecuador, Mexico and Venezuela, sustainability problems may arise owing to the heavy use of fossil fuels for final industrial and household consumption and for intermediate consumption in electric power generation. In these countries, hydrocarbons account for 80% to 90% of the TPES.

Lastly, there is a category of countries that have a combination of problems. For example, Cuba uses many renewable energy sources, but in inefficient combustion processes; the Dominican Republic and Panama show inefficiencies in the thermal transformation of imported fossil fuels; and Chile and Uruguay are almost wholly dependent on petroleum and hydroelectric power.

There are only two countries that do not fall into any of these categories, since their TPES consists of over 90% renewable sources not related to wood fuels and less than 2% petroleum: these are Paraguay, on the basis of its hydroelectric resources, and Costa Rica, which has the most complete and balanced renewable energy mix in the entire region.

Much of Costa Rica's TPES comes from geothermal and hydroelectric power, sugar cane products and wood and wind energy. An important piece of background information for understanding Costa Rica's results is that its dependence on hydrocarbons is apparent from its imports of derivatives, owing to the temporary closure of its refinery operations, but these imports are not considered in its TPES.

Apart from this general evaluation and ranking of the countries in relation to the Initiative, which is merely a snapshot of their situation in 2000, there are other areas of analysis that should be explored with respect to both their medium-term implications for this ranking and the composition and sustainability structure of the TPES.

The household sustainability index measures the importance of fuelwood in meeting families' basic energy needs, primarily for cooking, heating and hot water. A high index means not only that the country is heavily dependent on fuelwood to meet the population's needs, but also that further analysis should be carried out, in the form of a specific study, to determine the "sustainable portion" of the fuelwood used. This is important because a wide variety of situations can be found in the region in terms of fuelwood combustion technology and the conditions in which it is used, which determine both the efficiency of this kind of energy and its potential harmfulness to health.

The household sustainability index also provides insight into social characteristics such as the population's overall level of poverty and the access of rural and poor urban populations to higher-quality sources that are generally more expensive, but also more efficient, better performing and less demanding in terms of the time required to gather fuel, and that cause less

indoor pollution. The countries whose indices are below the 40% mark are heavy consumers of secondary hydrocarbons and may have higher per capita useful energy consumption —and therefore greater coverage of basic energy needs— than the other countries. On the other hand, indices of over 60%, such as those of Honduras, Guatemala, El Salvador and Nicaragua in Central America; Chile, Brazil, Colombia, Paraguay and Peru in South America; and Haiti in the Caribbean, reflect not only an overdependence on fuelwood, but also insufficient access to more efficient, higher-quality sources of energy.

Another indicator that gives some idea of the relative sustainability of energy systems is the indicator of polluting electricity generation, which measures the amount of $CO_2$ emitted in relation to the total amount of electricity produced (Ton $CO_2$/GWh). If this indicator were quantified in economic terms, it would measure the environmental cost of producing a unit of electric power. Costa Rica, Brazil, Paraguay and Uruguay have relatively cleaner electricity generation processes. The last three countries' low indices are due exclusively to their heavy dependence on hydroelectric power. Mexico, Nicaragua, Bolivia, Guatemala and the Dominican Republic have especially polluting generation processes in terms of $CO_2$ emissions. In Mexico and Bolivia, this is due to the predominance of hydrocarbons in the TPES; in the other countries, hydrocarbons play a lesser role (though their share is above 20% in all cases), meaning that pollution evidently results from less efficient thermal generation processes.

As stated earlier, the specific aim of this document is to analyse the sustainability of the primary energy supply as of 2000. In other words, it attempts to describe the state of affairs with respect to energy that year, drawing positive conclusions in some cases and raising questions in others.

The next step is to undertake a dynamic, as opposed to a purely static, analysis of this set of issues. Such an analysis would involve suggesting a number of possible scenarios that could take shape in the Latin American and Caribbean countries and observing the national, subregional and regional factors that affect their progress, so that those countries or subregions that are not on track to meet the Initiative target can implement policies that will bring them closer to that objective, while those that are on target but in danger of falling behind can refocus their practices and policies on the sustainable development of the energy sector.

To this end, it seems advisable to conduct, as soon as possible, more in-depth studies on the following topics:

(i) the renewable share of the various applications of fuelwood (on the basis of the methodology proposed by Brazil) in selected countries. This study should focus on those countries whose energy supply is heavily dependent on fuelwood and may include a high proportion of unsustainable wood energy;

(ii) problems and obstacles in implementing policies and encouraging initiatives to promote renewable energy sources in selected countries; and

(iii) the general, regulatory and economic conditions required for the successful adoption of modern technologies for using wind, geothermal and solar energy and urban waste combustion.

# I. INTRODUCTION

## 1. Background

The United Nations' Economic Commission for Latin America and the Caribbean, ECLAC, prepared this study on the status of new, renewable energy sources in Latin America and the Caribbean, as part of a joint project with the German Agency for Technical Cooperation (GTZ), with support from the Environmental Ministry in the State of Sao Paulo, Brazil, based on decisions at:

- Seventh Meeting of the Inter-Sessional Committee of the Forum of Ministers of the Environment of Latin America and the Caribbean, which set the target of ensuring that renewable energy sources account for 10% of the primary energy supply by 2010, which was reaffirmed in the Brazilian Energy Initiative, presented to the World Summit on Sustainable Development in Johannesburg, September 2002.

- The plan of action from the Johannesburg Summit itself, the final version of which recognizes the importance of meeting these goals.

- The United Nations' Sustainable Development Commission, which suggests implementing a regular review process to monitor the policies and instruments adopted to ensure inclusion of renewable energies within regional targets (CSD-UNDESA Conference, April 2003).

Likewise, it is necessary to specify that part of developing this paper involved technical meetings with the Environmental Ministry of the State of São Paulo, during which previously prepared studies were presented, discussed and revised. These included: "Renewable Energy: Traditional Biomass vs. Modern Biomass,"[1] which gave rise to the "Brazilian Energy Initiative", presented at the Johannesburg Summit.

## 2. The ECLAC/GTZ project

The main objective of the ECLAC/GTZ project, "Promoting Economic Development in Latin America and the Caribbean by Integrating Social and Environmental Policy Proposals", is to contribute to integrating economic and environmental policies within the sphere of the governments of Latin America and the Caribbean.

This forms part of the concept of sustainable development established by ECLAC and involves trying to integrate economic and environmental objectives as part of efforts to improve competitiveness.

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[1] Prepared by José Goldemberg, Minister of the Environment, State of São Paulo, and Suani Teixeira Coelho, Coordinator of the CENBIO Centre at the University of São Paulo.

The project is being implemented by ECLAC's Sustainable Development and Human Settlements Division. For some activities there are plans for the Commission's Natural Resources and Energy Unit to cooperate and participate.

The project's operating plan calls for achieving four results:

- The first relies on diagnostic and research tasks to examine and document different issues that lend themselves to combining environmental with economic and sectoral policies and their results.

- The second focuses on discussing and providing information about proposals for both institutional structures and instruments.

- The third result is regional in scope. It seeks to improve dialogue between actors from business, different spheres of government, environmental and other ministries concerned about the links between macroeconomics, trade and the environment in the global and regional spheres.

- The final result focuses on formulating public policies. It seeks to place the emphasis on studies and proposals for potential "green" markets, as well as reviewing successful experiences. It also involves preparing and discussing a strategy proposal for making the most of the opportunities thus identified.

By way of these four results, the immediate objective of the project is to provide the region's countries with technical assistance about practical ways of combining environmental policy objectives with those of economic and social policies, to create models for sustainable development.

# II. METHODOLOGY FOR CLASSIFYING RENEWABLE SOURCES AND INFORMATION SOURCES

## A. INFORMATION SOURCES

The different sources of information and statistics used to prepare this report are presented below.[2]

### 1. Information from national bodies

ECLAC's Executive Secretariat sent formal requests to 20 national institutions responsible for bioenergy, requesting specific information on subjects related to the renewability of forest energy for each case. Information was requested from Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, Ecuador, El Salvador, Guatemala, Haiti, Honduras, Mexico, Nicaragua, Panama, Paraguay Peru, the Dominican Republic, Uruguay and Venezuela. Between June and July 2003, official replies containing quantitative and qualitative information for each country, of enormous interest to the subject under discussion, were received from specialized bodies.

### 2. Information from international agencies

This study has also made significant use of technical information and statistics provided by:

- The Energy Economic Information System (SIEE) from the Latin American Energy Organization (OLADE), particularly data from its "Demand and Supply" inventory and national energy balance sheets (www.olade.org.ec ).

- The United Nations' Food and Agriculture Organization's Statistical Information System (FAOSTAT), particularly national data presented under the "Forestry Products" item (www.apps.fao.org) and a major study carried out to standardize forest energy terminology (UWET 2001, www.fao.org/forestru/fop).

- Statistical and methodological work from "Renewable Information 2002", published by the International Energy Agency (IEA) in November 2002, as part of its series, "IEA Statistics".

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[2] Some well-known international specialists in the subject of biomass in Latin America were contacted directly, among them, Miguel Trossero, Senior Forestry Officer with the Wood Energy Programme, Forestry Department, FAO; Carlos Repetto, Executive Secretary of the Latin American and Caribbean Working Group on Energization for Sustainable Rural Development (GLAERS); João Antonio Moreira Patusco, Advisor with the National Energy Policy Department of the Ministry of Mines and Energy, Brazil.

- Issue No. 19 of the "Survey of Energy Resources," 2001, presented by the World Energy Council (WEC) in 2002, with data on wind, solar, geothermal, hydro and biomass energy at the world and country levels (www.worldenergy.org).

- The International Energy Database and Country Profiles, published by the US Department of Energy (USDoE) within its "Energy Information Administration" system (www.eia.doe.gov).

## B. METHODOLOGY FOR ORGANIZING AND CLASSIFYING ENERGY SOURCES AND CATEGORIES

### 1. Definition of Total Primary Energy Supply

For the purposes of this study, the following definitions have been used:

**Primary energy**: the natural resources directly or indirectly available that suffer no chemical or physical change for energy use. The main sources normally included in Latin American and Caribbean countries' energy balance sheets are: oil, natural gas, coal, hydroelectricity, woodfuel and other by-products; biogas; geothermal, wind, nuclear, solar and other primary sources, such as bagasse and agricultural or urban residues.

**Secondary energy**: the set of energy products that undergo physical or chemical transformation to make them more suitable for their end use. In general, these include: fuel oil (also known as fuel or bunker oils), diesel oil (or gas oil); gasolines (of different octanes, with or without lead); kerosene; liquid gas from oil; aviation kerosene and gasoline; naphtha; refinery gas; electricity; charcoal; gases; coke; blast furnace gas.

**Total supply**: quantity of energy (primary and secondary) available to satisfy a country's energy needs, both for transformation processes and final consumption. Therefore:

**TOTAL SUPPLY = Production + imports – exports +/- change in inventories inventories – energy not used**

As a result, the TPES[3] is calculated using the formula above, but only for the subject of this study, primary energy.

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[3] Total Primary Energy Supply.

## 2. The concept of the renewability of energy sources

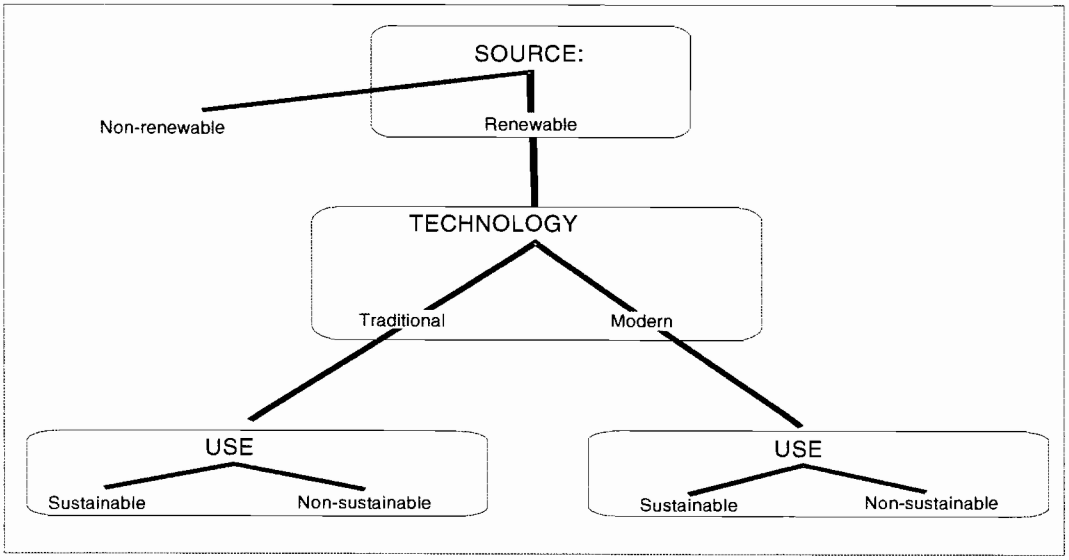
The energy statistics regularly published by international bodies today make no clear distinction between renewable and non-renewable energy. The best reference available to date at the world level is provided by the International Energy Agency in its study "Renewables in Global Energy Supply" from November 2002, which accurately describes the categories of fossil fuels and nuclear energy.

Hydroelectric energy, despite not being broken down among large and small generators, is also satisfactorily characterized. The data for geothermal, wind, solar and tidal power are also clear and easy to identify.

The main difficulty arises from the category that the AIE refers to as "combustibles, renewable & waste", which includes both the sustainable and the non-sustainable part of biomass.

The concepts of energy "renewability" and "sustainability" have been a subject of intense debate. In this document, renewability is defined as an attribute of the energy source, and sustainability as an attribute of the way the source is used.

Although this paper does distinguish between "modern" and "traditional" biomass, these terms are common and reflect both the technology used to extract forest energy and its end use. Thus, energy from biomass used to heat households or prepare food appears as a traditional use (or technology), while modern use refers to biomass used to generate electricity and steam, and to produce biofuels. ECLAC's conceptual framework can therefore be presented graphically as follows:[4]




[4] Gallopin (1995).

The non-sustainable portion of biomass comes essentially from fuelwood from deforestation. Sustainable biomass includes animal, vegetable and urban waste, and woodfuel obtained in a sustainable fashion.

The sustainable form of fuelwood consumption may occur through:

- collecting dry branches, when these result from pruning;
- cutting trees at a rate lower than their natural regeneration; and
- cutting trees followed by replanting the species cut down.

In the Scandinavian countries, for example, it can be said that all fuelwood burned for household consumption is sustainable, which is certainly not what occurs in developing countries, particularly in Latin America, where fuelwood biomass plays a major role in TPES. In fact, in some Central American countries, as mentioned below, fuelwood contributes more than 40% of the TPES.

## C. CATEGORIZING BIOFUELS

Biofuel categories, as defined using the system proposed recently by the FAO, follow.

### 1. Woodfuels

This category (also known as "forest energy") includes all kinds of biofuels derived directly or indirectly from trees and shrubs.

The definition of forest used in the FAO forestry resource review,[5] 1990, is very broad and includes forests with a minimum of 20% crown cover of trees in developed countries and 10% in developing countries. Woodfuels also include biomass from silvicultural activities (clearing, trimming), extraction and exploitation (tops, roots, branches), as well as industrial by-products derived from primary and secondary forestry manufacturing, which are used as fuel. Also included are woodfuels from silviculture plantations whose purpose is energy.

Based on their origin, woodfuels fall into three groups: direct woodfuels, indirect woodfuels and recovered woodfuels:

- Direct woodfuels: wood extracted directly from a) forests (natural forests and plantations, with a minimum crown cover of 10% of an area larger than 0.5 hectares); b) other wooded lands (with a minimum crown cover of 5% to 10% of the total area, in which trees can reach at least 5 m upon maturing in situ; or with a crown cover of over 10% of the area, in which trees cannot reach at least 5 meters in height in situ;

[5] FAO, 1995.

and shrub and bush cover; and c) other lands used to supply energy on demand and including inventoried (recorded in official statistics) and non-inventoried woodfuels. Direct woodfuels are burned directly or transformed into another fuel, such as charcoal, pyrolysis gases, pellets, ethanol and methanol.

- Indirect woodfuels: generally these are by-products from primary (sawmills, particle board factories, pulp and paper mills) and secondary (joinery, carpentry) wood industries. The main indirect fuels include: sawmill rejects, slabs, edging and trimmings, sawdust, shavings, chips and black liquor. These fuels are burned directly or turner into another fuel, such as charcoal, pyrolysis gases, pellets, ethanol, methanol.

- Recovered woodfuels: fuelwood biomass from all other economic and social activities outside the forestry sector. Generally, this category includes: construction waste, building demolition, charging trays, wooden crates and containers, etc., which are burned as is or turned into chips, pellets, briquettes and dust.

In its forest energy accounts, this study includes four kinds of products as woodfuels: fuelwood, charcoal, black liquor and others, defined as follows:

- Fuelwood: includes "wood in the rough" in small pieces (fuelwood), chips, pellets and/or dust from isolated trees and forests, as well as the by-products of the wood industry and recovered wood products. These retain the original, basic structure of the wood and can be used directly or after being transformed into another woodfuel such as charcoal. When necessary, fuelwood can be converted into more convenient fuels, such as chips and pellets, without major physico-chemical transformations.

  (i) chips: wood that has deliberately been reduced to small pieces from wood in the rough or residues suitable for energy use;
  (ii) wood pellets: can be considered a fuel derived from the autoagglommeration of woody material, the result of a combined application of heat and high pressure in an extrusion machine.

- Charcoal: a solid residue derived from carbonization, distillation, pyrolysis and torrefaction of wood (from tree trunks and branches) and wood by-products, using continuous or batch systems in different types of kilns: pit, brick and metal. It includes charcoal briquettes. These are produced from charcoal, which, after crushing and drying is moulded (often under high pressure), generally with the admixture of binders to form uniform pieces.

- Black liquor: in woodpulp production, while the wood is baked in the digester the lignin dissolves, producing black liquor —a mixture of lignin, chemicals and water, which is separated from the pulp; the lignin in black liquor is burned in the recovery boiler to generate steam.

- Other woodfuels: this refers to a wide range of liquid and gaseous fuels from fuelwood and charcoal, which are the product of pyrolytic or enzymatic processes, such as pyrolysis gases, ethanol, and methanol. These products are of growing interest but for now are not as important as other energy products.

## 2. Agrofuels

These are fuels obtained from agricultural biomass and by-products. This category mainly includes biomass derived directly from crops produced for the purpose of being used as fuels and agricultural, agroindustrial and animal by-products.

- Fuelcrops: plants cultivated on plantations or farms as raw materials in producing biofuels. These crops can be produced on land farms (yucca, sugar cane, euphorbia), sea farms (algae) or (tank-based) freshwater farms. Fuelcrops produced on land can be classified as: sugar/starch, oleaginous and other energy crops.

  (i) Sugar/starch crops: these are basically used to produce ethanol (ethyl alcohol) for fuel, alone or mixed with gasoline, used mainly in transportation. The ethanol can be produced by fermenting glucose from sugar-containing plants, such as sugar cane, or starchy materials after hydrolysis.

  (ii) Oleaginous crops: These include oleaginous plants (such as the sunflower, rapeseed, etc.) planted for direct energy use involving vegetable oil extracts, or as a raw material to be turned into a substitute for gas oil, using a trans-esterification process.

  (iii) Other energy crops: specialized crops and plants used more recently for producing energy, which include: miscanthus, spartina spp. cyperus longus, arundo donax and phalaris arundinacea.

  (iv) Agricultural by-products: these consist mainly of vegetable by-products and material from production, crops, transportation and production in agricultural zones. This category includes, among others, corn cobs and stalks, wheat husks and stalks, peanut shells, coconut shells, cotton stalks, mustard stalks, etc.

  (v) Agroindustrial by-products: by-products from food processing industries, such as sugar cane bagasse, rice husks, coconut pith, fibre and shells, peanut shells, olive pressing residues, etc.

  (vi) Animal by-products: manure and other excreta from cattle, horses, pigs and poultry and, to a lesser degree, human beings. This can be dried and used directly as fuel or turned into biogas using fermentation.

(vii) Biogas: a by-product of the anaerobic fermentation of biomass, mainly animal wastes, carried out by bacteria. This consists mainly of methane gas and carbon dioxide.

### 3. Urban (or municipal) by-products

These consist of two types of biomass waste produced by urban populations: solid by-products and gaseous or liquid by-products, produced in cities and towns (called municipal by-products).

- Solid municipal biofuels: these include by-products from residential, commercial, industrial, public and tertiary sectors collected by local authorities for elimination in a central place where they are usually incinerated to produce heat, energy or both. These also include hospital wastes.

- Gaseous/liquid municipal biofuels: biofuels mainly from anaerobic fermentation (biogas) of solid and liquid municipal wastes, which may be gases from dumps or residual sludge.

## D. PROPOSED MODEL

Given that world energy statistics still do not distinguish between renewable and non-renewable fractions of biomass, it is hard to estimate the amount of energy available (supply) and transformed (consumption) in a country that can be considered genuinely renewable, particularly if this refers to the question of the "sustainability" of the fuelwood biomass.

Brazil's Ministry of Mines and Energy (Patusco, 2002) has proposed a model in this sense, based on sectoral consumption available in the National Energy Balance Sheet (BEN) and information from the Brazilian Institute of Geography and Statistics (IBGE). Based on this consumption, for 2000, "renewability fractions" were assigned according to the sector or subsector of fuelwood consumption. Using this scheme, the percentages of renewable fuelwood used in Brazil in different sectors, by application and use, are:

- Agriculture = 74%
- Charcoal = 71%
- Residential = 90%
- Industrial (paper) = 100%
- Industrial (ceramic and food) = 44.5%
- Industrial (other uses) = 0%

Fuelwood renewability
Percentages

B R A Z I L
2000

At first, this study used these percentages as reference points for disaggregating "sustainable" and "non-sustainable" fuelwood biomass. The purpose of this first approach was to focus discussion on a "minimum (or standard) methodology for the countries of Latin America, taking into account specific local conditions. According to the terminology proposed in Part B, from now on the term biomass "fractions of sustainability" will be used.

Conceptually speaking, this methodology is based on crossing data from:

- national balance sheets, based on data from ministries or secretaries of energy in different countries, and information from OLADE; and
- national sector information (data from national bodies responsible for maintaining statistics for different sectors, such as forestry resources, industry, and others).

The accuracy of calculating these "sustainability fractions" becomes increasingly important (in terms of the policy analysis of the information) the larger fuelwood's share of the country's energy supply. Thus, the Central American countries and Haiti, which depend heavily on fuelwood within their energy matrix, will be more affected by the accuracy of the "sustainable biomass" calculation. Since this deals basically with fuelwood, it could be referred to as "sustainable forest energy".

A rigorous analysis should therefore use the methodology proposed for Brazil, adapt it to the specific conditions and information available for different countries in the region, and apply it on the basis of data controls and confirmations from national energy balance sheets and sectoral information for each country. This process has been applied in this study.

## E. THE BREAKDOWN OF RENEWABLE ENERGY CATEGORIES

Based on the information and categories described above, this study proposes to quantify the contribution from the different categories of sources to the Total Primary Energy Supply of each country[6] in the region. The renewable sources considered were:

- Hydroenergy (large- and small-scale) - 100% renewable.
- Geothermal - 100% renewable.
- Sustainable forest energy,[7] the portion of the sustainable woodfuel biomass used for residential, industrial, agricultural and cultural energy. - 100% renewable.

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[6] Twenty countries were considered for which information was available and fuelwood or renewable sources represented a significant portion of their TPES. For the six Caribbean countries, given the low share of renewable energy in general and fuelwood in particular, results are provided at the subregional level. These countries are: Barbados, Grenada, Guyana, Jamaica, Suriname and Trinidad and Tobago.

[7] Also referred to in the literature as "sustainable woodfuel".

- Non-wood related sustainable bioenergy such as agrofuels (from cane and other biomass residues) and municipal by-products[8] - 100% renewable.

- Other renewable technologies (wind and solar) - 100% renewable.

By subtracting the category of renewable sources, combined with hydrocarbons, nuclear and coal, we should be left with the portion of non-sustainable biomass or forest energy,[9] that is the part of fuelwood resulting from deforestation (expansion of the agricultural frontier, illegal logging), which is therefore non-sustainable.

[8] Given the important role played by cane products within the bioenergy category in Latin America, the statistical figures for this report distinguish between "cane products" and "other biomass".

[9] Also called Non-Sustainable Wood Fuel.

# III. COUNTRY ANALYSIS

Based on the outline and concepts described above, data for the year 2000 from 26 Latin American and Caribbean countries has been gathered and organized.

The disaggregated data for 20 of the region's countries have been individually analysed, while for the English-speaking Caribbean (Barbados, Guyana, Trinidad and Tobago, Jamaica, Grenada and Surinam) the study has been carried out at the subregional level (see chapter V).

Initially, the information was broken down into renewable and non-renewable sources, particularly sustainable biomass, using the method proposed by Brazil. The result of this first calculation was then officially sent to the competent institutions in all 20 countries to request their remarks and eventual numerical changes based on direct national information.

Twelve countries replied officially to the ECLAC request: Chile, Mexico, Honduras, Uruguay, Paraguay, Peru, Cuba, El Salvador, Guatemala, Brazil, Bolivia and Argentina. Using the information obtained directly and officially from countries, the national data was reviewed and the sustainable biomass portions re-calculated.

General information on policies for promoting renewable sources and an analysis of study results for the role of renewable sources in the TPES for each country follow.

## A. ARGENTINA

The importance of the contribution made by renewable resources as alternative energy sources in the rural sector has been encouraged through PAEPRA (a programme for providing the rural population with electrical power) carried out by the Ministry of Public Services and Works through the national job creation office (*Dirección Nacional de Promoción del Empleo).* It seeks to provide basic electrical power for lighting and communications using renewable energy sources (solar, wind, biomass and mini-hydro electric power).

As a result of the programme, in 2000 the *Sociedad Cooperativa Popular Limitada* (SCPL) and the Spanish firm Gamesa Eólica SA agreed to install 16 new windmills at Comodoro Rivadavia, Argentina, a decision which will double the installed capacity of the windmill park, requiring an investment of almost US$ 7 million. The wind generators were added to ten already in place.

An analysis of Argentina's Energy Balance Sheet, regarding supply and total consumption of primary energy in 2000, reveals that:

- this country's TPES depends heavily on hydrocarbons, with a smaller contribution from coal and nuclear power;

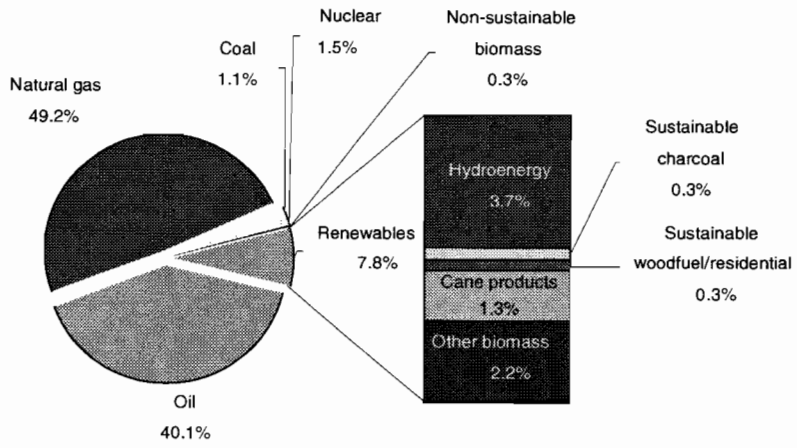
- hydroenergy's contribution is not decisive to primary supply;
- fifty three percent of primary fuelwood is processed to produce charcoal and 37% goes to residential use;
- the contribution from cane products accounts for a substantial percentage.

Something similar occurs with "other primaries", that is, the category including other biomass (agrofuels other than cane and municipal by-products), wind and solar energy. Based on data from the World Energy Conference (WEC), the installed capacity for wind generation is 14 MW (megawatts) and for solar it is 5 MW, both rather negligent amounts in terms of their percentage of total installed capacity.

Based on this data and information confirmed using sectoral data from FAOSTAT, supply quotas for the different primary energy categories have been calculated and then successively standardized using kBEP (thousands of oil-equivalent barrels).

The composition of the TPES in percentages in 2000 is presented in the following figure:

Figure III.1
**ARGENTINA: TOTAL PRIMARY ENERGY SUPPLY (TPES), 2000**




**Source**: Own calculations based on SIEE figures from the Latin American Energy Organization (OLADE); the Food and Agriculture Organization (FAO), FAOSTAT; and Argentina's energy balance sheet.

An analysis of this figure reveals that:

- altogether the contribution from renewable energy sources is rather low, accounting for just 7.8% of the TPES;
- within this percentage, the supply of hydroenergy is significant (3.7%), as is renewable, non-woodfuel biomass (cane products and other biomass, 3.5%);
- the role of the renewable part of fuelwood and charcoal is rather low (0.6%);
- the contribution from new renewable technologies is practically zero (wind, solar, geothermal).

# B. BOLIVIA

## 1. Rural electrification and renewable sources

In 1999, the new regulation governing electric sector resources for rural electrification (*Reglamento Sobre Recursos Provenientes del Sector Eléctrico Destinados a Electrificación Rural*) was passed and that same year 78 projects worth about US$ 12.4 million were completed. In 2000, a sub-programme for renewable energy (*Electrificación Rural con Energías Renovables a traves del Proceso de Participación Popular*) started up.

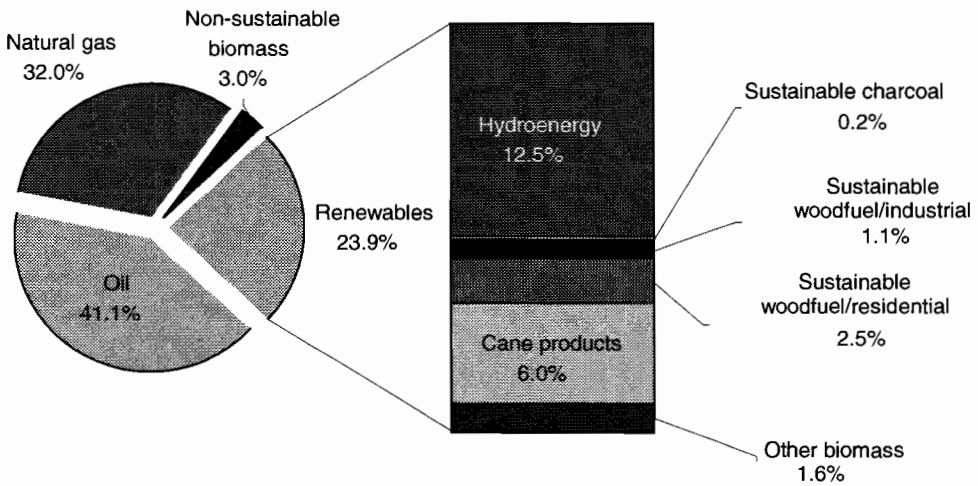
## 2. Study results

An analysis of Bolivia's energy balance sheet reveals that:

- the country's TPES depends heavily on hydrocarbons, with no contribution from coal and nuclear power;
- hydroenergy's contribution to primary supply is significant;
- 11% of primary fuelwood goes to a transformation centre for charcoal production, 55% is consumed in industry, and 44% goes to residential use;
- the contribution from cane products is substantial, percentage wise;
- "other primaries" account for a very small share.

Based on this data and contrasting this information with sectoral data from FAOSTAT, the TPES breakdown is presented in the following figure:

Figure III.2
**BOLIVIA: TOTAL PRIMARY ENERGY SUPPLY (TPES), 2000**




**Source**: Own calculations based on SIEE figures from the Latin American Energy Organization (OLADE); the Food and Agriculture Organization (FAO), FAOSTAT; and Bolivia's energy balance sheet.

An analysis of this figure reveals that:

- the contribution from renewable energy sources as a whole is significant, accounting for 23.9% of the TPES;
- within this percentage, the supply of hydroenergy (12.5%) is significant;
- the amount of renewable non-woodfuel biomass (cane products and other biomass, 7.6%) is also significant;
- the role of the renewable part of fuelwood and charcoal is smaller;
- contributions from new renewable technologies such as wind, solar and geothermal power do not appear.

## C. BRAZIL

### 1. Rural energization and renewable sources

Between 1996 and 1999, the state and municipal energy development programme (*Programa de Desarrollo Energético de Estados y Municipios, PRODEEM*) of the Ministry of Mines and Energy (MME), served the news of more than 500,000 people in over 2,000 communities. The programme involved providing electrical power to schools, health centres, community centres, water pump systems, and other collective benefits, primarily of a social nature.

In 2000, PRODEEM served almost 104,000 people in 219 municipalities. The Inter-American Development Bank (IDB) proposed to finance a project for providing electric power to rural residences, so the MME and the IDB jointly prepared the PRODEEM Plan of Action, implemented with a non-reimbursable fund of US$ 9 million.

In rural areas, the "Luz en el Campo" national rural electrification programme (*Programa Nacional de Electrificación Rural*) set as its goal for its first stage (to 2002) providing electrical power to one million rural homes, benefiting five million people involving a demand for resources worth 2.7 million reales. In 2000, contracts with over 40 concessionaires were signed.

### 2. Study results

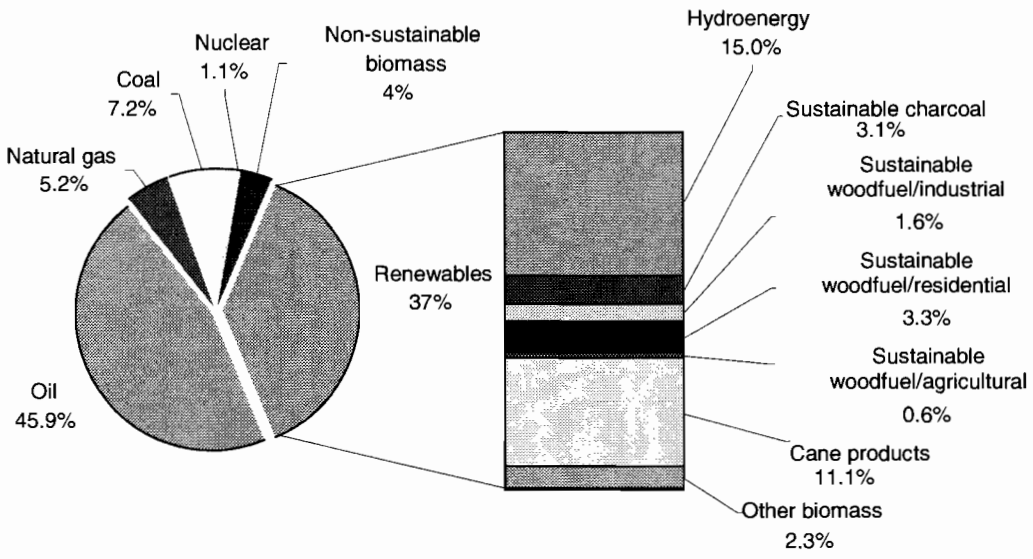
An analysis of Brazil's energy balance sheet reveals that:

- the country's TPES depends heavily on oil, with some contribution from natural gas, coal and nuclear energy;
- the role of hydroenergy appears as very significant within primary supply;
- 36% of primary fuelwood goes to centres for charcoal production, 24% to industry, 30% to residential use, and 7% to agriculture;
- the contribution from cane products accounts for a very significant percentage, approaching that of hydroenergy;

- the contribution from "other primaries" is virtually non-existent. Based on WEC information, the installed capacity for wind generation amounted to just 18 MW of energy in 2000.

Based on this information and examining FAOSTAT sectoral figures, the percentage breakdown of the TPES in 2000 is as follows:

Figure III.3
**BRAZIL: TOTAL PRIMARY ENERGY SUPPLY (TPES), 2000**




**Source**: Own calculations based on SIEE figures from the Latin American Energy Organization (OLADE); the Food and Agriculture Organization (FAO), FAOSTAT; and Brazil's energy balance sheet.

An analysis of this figure reveals that:

- the contribution from renewable energy sources as a whole is significant, accounting for 37% of the TPES;
- within this percentage, the supply of hydroenergy (15%) and renewable non-fuelwood biomass (cane products and other biomass, 13%) is significant;
- the role of the renewable part of fuelwood and charcoal is also significant (9%);
- in percentage terms, the contribution from new renewable technologies, wind, solar and geothermal energy, is virtually nil.

# D. CHILE

## 1. Rural electrification and renewable sources

In 2000, in Chile almost 14,000 rural households were provided with electricity, increasing the coverage of rural electrification from 76% in 1999 to 78% in 2000. Similarly, the National Energy Commission (CNE) and the United Nations Development Programme (UNDP) implemented four pilot projects based on renewable energy, consisting of a wind-diesel project on Tac Island and three micro-hydroelectric generators in indigenous zones.

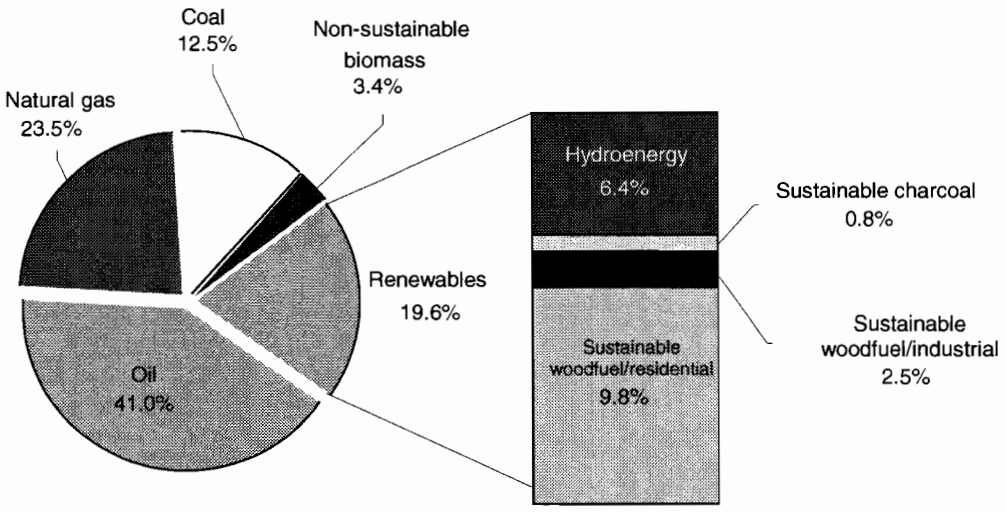
## 2. Study results

An analysis of Chile's energy balance sheet reveals that:

- the supply of primary energy depends heavily on hydrocarbons (almost two-thirds of the TPES), with a small contribution from coal;
- hydroenergy's contribution to primary supply is not significant;
- 7% of primary fuelwood goes to charcoal production, 27% to industry and 66% to residential sector consumption;
- cane products are non-existent;
- "other primaries" also play a very small role. According to information from the WEC, wind power contributes just 28 kBEP (thousands of oil-equivalent barrels) so is very slight and not represented percentage wise.

Based on this data and sectoral information from FAOSTAT, the percentage breakdown of the TPES in 2000 was as follows:

Figure III.4
**CHILE: TOTAL PRIMARY ENERGY SUPPLY (TPES), 2000**




**Source**: Own calculations based on SIEE figures from the Latin American Energy Organization (OLADE); the Food and Agriculture Organization (FAO), FAOSTAT; and Chile's energy balance sheet.

An analysis of this figure reveals that:

- the contribution from all renewable energy sources is slight, accounting for 19.6% of the TPES;
- almost one-third of this share is from hydroelectric sources, making the supply of hydroenergy significant (6.4%);
- the role of the renewable part of fuelwood and charcoal (13.1% of total) is particularly important, mainly due to their residential sector use;
- the contribution of new, renewable technologies such as wind, solar and geothermal energy is virtually nil.

## E. COLOMBIA

### 1. Rural electrification and energy efficiency

The Mining Energy Planning Unit (UPME) has developed a strategic plan for rational and efficient use of energy, in a context of open markets and deregulation. The purpose of this plan is to establish the strategies for satisfying the population's needs for energy, making the most rational and efficient use of the resources available, promoting a sustainable energy economy by

including and developing new technologies and processes, and encouraging a culture of citizenship.

In 2001[10] the financial support fund for energy in non-connected zones (ZNI) was created and a levy established of one Colombian peso per KWh dispatched in the wholesale energy exchange, to create the financing necessary to establish and develop a new institutional and administrative system for providing energy in the ZNIs.

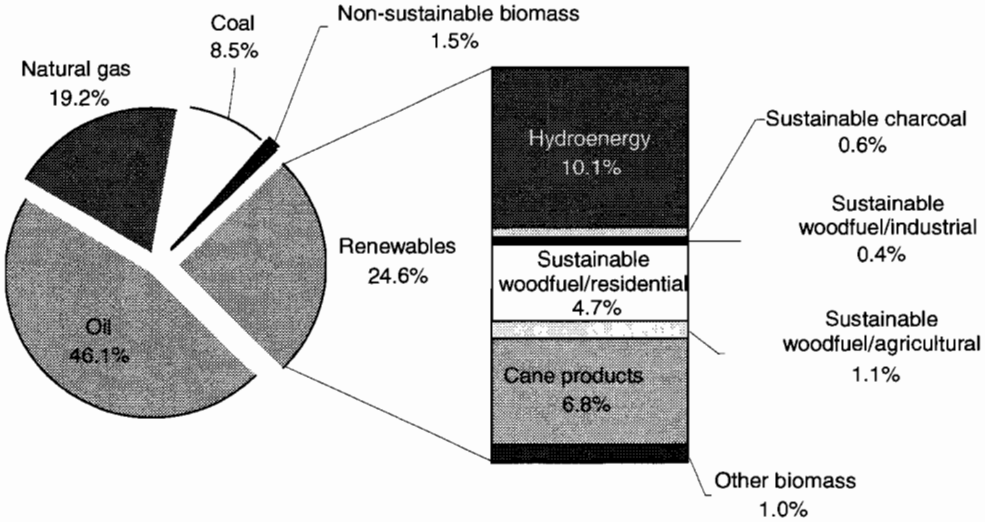
## 2. Study results

Colombia's energy balance sheet reveals that:

- the supply of energy depends heavily on hydrocarbons, which represent almost two-thirds of the TPES, with little contribution from coal;
- hydroenergy's contribution to primary supply is significant, at 10%;
- charcoal production accounts for 10% of fuelwood use; 9% for industry, 63% for residential use, and 18% for agriculture;
- the contribution from cane products is substantial, almost 7%;
- "other primaries" are virtually nil.

With this data and sectoral information from FAOSTAT, the percentage breakdown of the TPES in 2000 was as follows:

Figure III.5
**COLOMBIA: TOTAL PRIMARY ENERGY SUPPLY (TPES), 2000**




**Source**: Own calculations based on SIEE figures from the Latin American Energy Organization (OLADE); the Food and Agriculture Organization (FAO), FAOSTAT; and Columbia's energy balance sheet.

[10] Resolution 1-037/2001, Public Information Service of the national commission governing grants of different sorts of rights (*Comisión Nacional de Regalías*).

An analysis of this figure reveals that:

- the contribution from the group of renewable energy sources is rather substantial, accounting for one-fourth of the TPES;
- within this percentage, the supply of hydroenergy (10.1%) and renewable non-fuelwood biomass (cane products and other biomass, 7.8% total) are significant;
- the role of the renewable part of fuelwood and charcoal (6.8% of the total) is also significant, particularly residential fuelwood use;
- the contribution from new renewable technologies (wind, solar, geothermal) is non-existent.

## F. COSTA RICA

### 1. Renewable sources and energy efficiency

Law No. 7200 (and its amendments) has been considered very successful worldwide, since it made it possible to develop 26 hydroelectric projects that have cooperated with the Instituto Costarricense de Electricidad (ICE) to improve electrical supply. Moreover, the first BOT project was carried out, involving 27 MW of geothermal power and started up in 1999. Similarly, with support from private investors, new, renewable energy sources have been developed and the country now generates 42.5 MW in wind power, thus contributing to greenhouse gas reduction.

Law No. 7447, the regulation governing rational energy use, seeks to create an instrument for efficient energy use in the country's different productive activities, to achieve optimum use of energy investments on both the supply and demand sides. Thus, efficient energy use could become the most important source of clean energy in Costa Rica. Applying this Law has brought the country substantial savings in energy, of about US$ 8 million annually. However, much remains to be done since the legislation suffers from several shortcomings that require constant review.

### 2. Study results

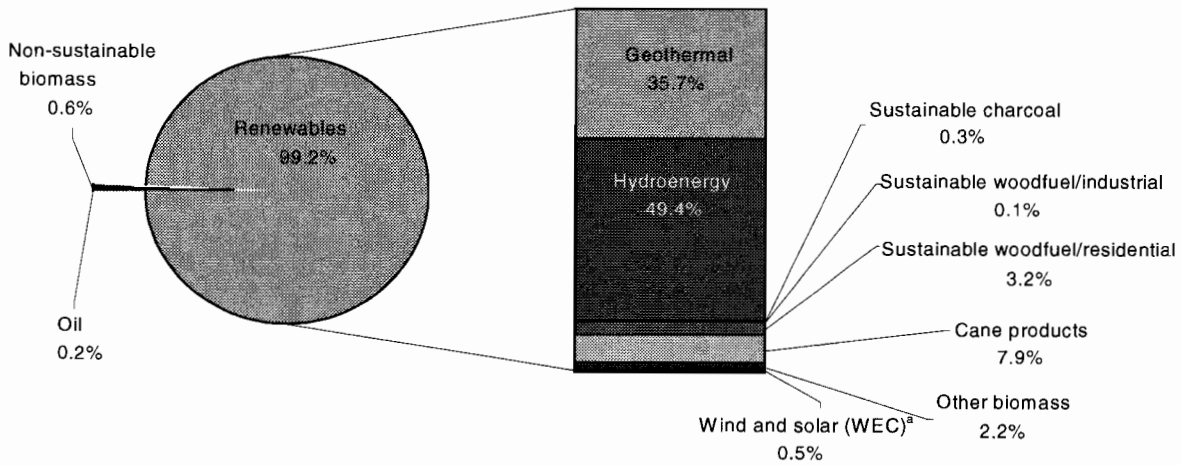
An analysis of Costa Rica's energy balance sheet reveals that:

- the TPES is completely linked to renewable energy sources, for lack of a significant oil supply (just 16,500 barrels in 2000);
- hydroenergy's contribution to primary supply is significant; geothermal power also plays an important role in the country's TPES;
- the main use of primary fuelwood is residential consumption, at 85%, while the remaining 15% goes to producing charcoal;
- the contribution from cane products is substantial;

- "other primaries" for now play a reduced but still significant role. According to the WEC, installed capacity for wind power generation had already reached 46 MW in 2000, the largest in Latin America for this item.

With this data and sectoral information from FAOSTAT, the percentage breakdown of the TPES in 2000 was as follows:

Figure III.6
**COSTA RICA: TOTAL PRIMARY ENERGY SUPPLY (TPES), 2000**




**Source**: Own calculations based on SIEE figures from the Latin American Energy Organization (OLADE); the Food and Agriculture Organization (FAO), FAOSTAT; and Costa Rica's energy balance sheet.
[a] World Energy Council.

An analysis of this figure reveals that:

- the importance of renewable energy sources is absolute, with these accounting for 99.2% (the highest in Latin America);
- hydroenergy (49.4%) and geothermal (35.7%) power account for most of this percentage;
- renewable non-woodfuel biomass (cane products and other biomass) account for 10.1%;
- the role of the renewable part of fuelwood and charcoal (total de 3.6%) is rather low;
- even lower, but still significant, is the contribution from new, renewable technologies, such as wind (0.5% of the TPES).

## G. CUBA

### 1. Renewable sources and energy efficiency

For some time Cuba has been negotiating the participation of foreign capital in the use of renewable energy sources, particularly energy in sugar cane bagasse. Other renewable sources have also continued to develop, primarily to support rural electrification.

Energy use has fallen 15% in the decade, with two-thirds of this reduction reflecting the launching of the urban energy saving programme (PAEC) that began at the end of the 1990s. By the late 1990s, the country had invested far more in energy efficiency than it had during the three previous decades.

The imported energy supply coefficient of GDP fell by 37% in the past decade, the result of Cuba developing natural sources and increasing energy efficiency.

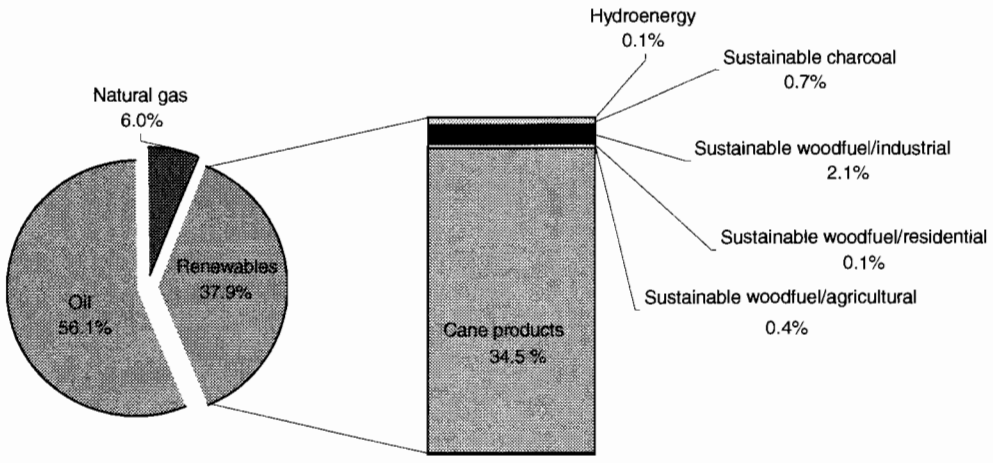
### 2. Study results

Cuba's energy balance sheet reveals that:

- hydrocarbons (mainly oil) dominate the TPES;
- locally produced natural gas is starting to account for a growing share;
- hydroenergy's contribution to primary supply is virtually nil;
- 20% of primary fuelwood goes to charcoal production, 41% to industry, 2% to residential use, 11% to agriculture, and 16% to the construction sector;
- the contribution from cane products is among the region's highest, accounting for over one-third of the TPES;
- "other primaries" are absent.

With this data and sectoral information from FAOSTAT, the percentage breakdown of the TPES in 2000 was as follows:

Figure III.7
**CUBA: TOTAL PRIMARY ENERGY SUPPLY (TPES), 2000**




**Source**: Own calculations based on SIEE figures from the Latin American Energy Organization (OLADE); the Food and Agriculture Organization (FAO), FAOSTAT; and Argentina's energy balance sheet.

This reveals that:

- the total contribution from renewable energy sources is significant, as they account for 37.9% of the TPES;
- the supply of hydroenergy is virtually nil (0.1%), while renewable non-woodfuel biomass (cane products) plays a major role (34.5%);
- the role of the renewable part of fuelwood and charcoal (3.3% of the total) is rather limited;
- there is no contribution from new, renewable (wind, solar, geothermal) sources.

Cuba has no "non-sustainable biomass" because, based on official information from the Ministry of Science, Technology and the Environment, the country: "has achieved sustainable production of fuelwood and charcoal, through reforestation programmes ..."

# H. ECUADOR

## 1. Renewable sources, efficiency and rural electrification

In 2000, a major concession for the 213 MW Marcel Laniado (ex- Daule-Peripa) hydroelectric power station was granted. This project will be run by a private consortium for 50 years, during which the national electricity council (CONELEC) will certify the availability of and sell the energy thus generated.

The Ministry of Energy and Mines is developing a renewable energy programme in seven Amazon border provinces, using solar power for 482 schools and 94 health centres, along with a 22-project programme involving small hydroelectric generators.

Since 1999, the government has promoted an energy saving programme in several cities. To do so, it signs agreements for publicity with the Ministry of Education and Culture, universities and other bodies.

As part of its decentralized rural electrification programme, 18 solar power systems were installed in schools in the province of Pastaza and a health centre; moreover a cooperation agreement was signed for providing electric power to frontier zones.

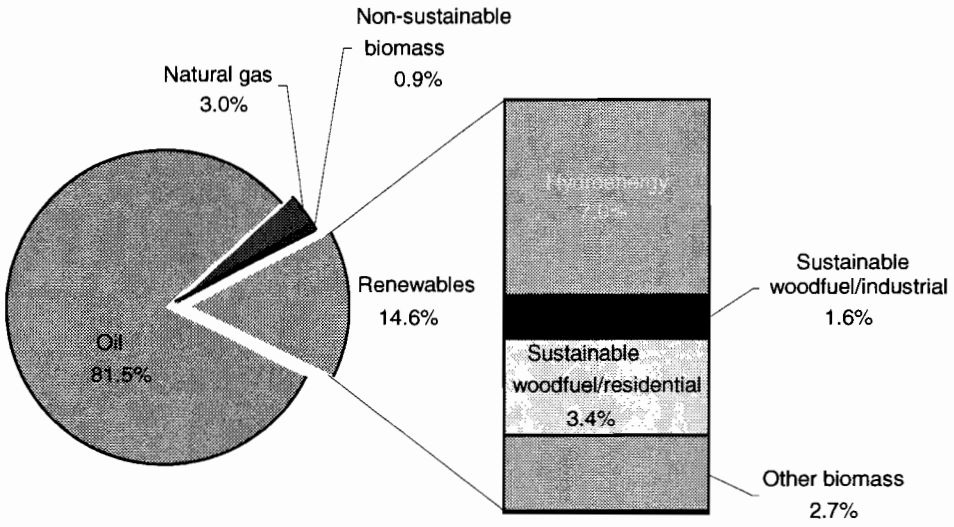
## 2. Study results

Ecuador's energy balance sheet reveals that:

- hydrocarbons, especially oil with more than 80%, dominate the supply of primary energy in the country;
- hydroenergy's contribution to primary supply is not decisive to supply;
- 93% of primary fuelwood goes to residential use and just 7% is consumed in industry;
- there is no record of the use of cane products;
- the "other primaries" item is rather small.

With this data and sectoral information from FAOSTAT, the percentage breakdown of the TPES in 2000 was as follows:

Figure III.8
**ECUADOR: TOTAL PRIMARY ENERGY SUPPLY (TPES), 2000**




**Source:** Own calculations based on SIEE figures from the Latin American Energy Organization (OLADE); the Food and Agriculture Organization (FAO), FAOSTAT; and Argentina's energy balance sheet.

An analysis of this figure reveals that:

- the contribution from renewable energy sources as a whole is rather low, accounting for just 14.6% of the TPES;
- among renewables, the supply of hydroenergy is significant (7.0%), while renewable non-woodfuel biomass (2.7%) is minor;
- the role played by the renewable part of fuelwood is rather slight, with it going mainly to residential use (3.4%);
- new renewable technologies (wind, solar, geothermal) are not represented in the TPES, despite Ecuador's enormous potential for geothermal power generation.

## I. EL SALVADOR

### 1. Study results

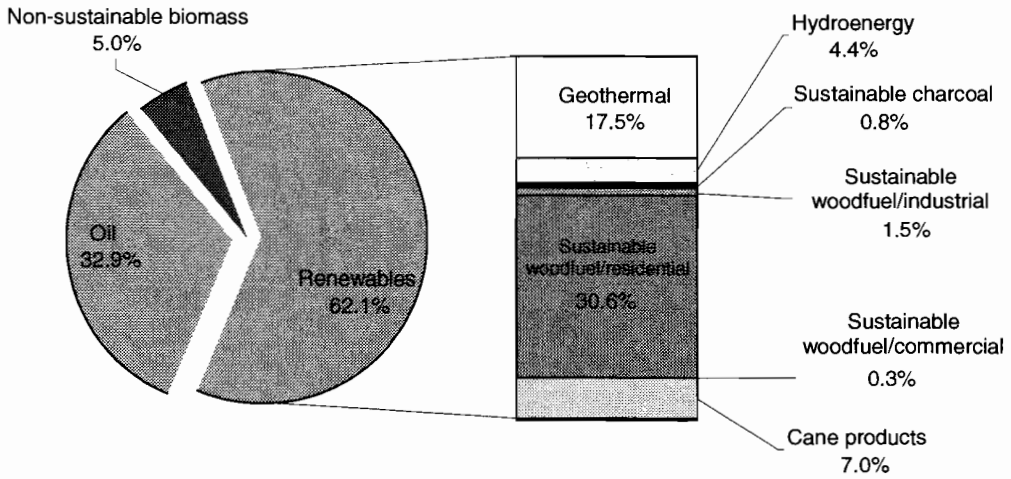
El Salvador's energy balance sheet reveals that:

- imported oil plays a major role in the country's energy supply, accounting for one-third of the TPES;
- hydroenergy's contribution to primary supply is not decisive;

- primary fuelwood accounts for almost one-third of the TPES. This goes mainly to family consumption, with 90%, while 3% goes to charcoal production, and 7% is consumed in industry;
- the contribution from cane products is substantial, higher than that of hydroelectricity;
- sources defined as "other primaries" are not consumed.

With this data and sectoral information from FAOSTAT, the percentage breakdown of the TPES in 2000 was as follows:

Figure III.9
**EL SALVADOR: TOTAL PRIMARY ENERGY SUPPLY (TPES), 2000**




**Source**: Own calculations based on SIEE figures from the Latin American Energy Organization (OLADE); the Food and Agriculture Organization (FAO), FAOSTAT; and Argentina's energy balance sheet.

An analysis of this figure reveals that:

- the contribution from all renewable energy sources is very important, accounting for more than 62% of the TPES;
- among renewables, geothermal power's share (17.5%) stands out, while hydroenergy (4.4%) and renewable non-woodfuel biomass (cane products 7.0%) play somewhat less important roles;
- due to its importance to family consumption, the contribution from renewables to the country's TPES (33.2%) is fundamental, particularly in the case of residential use (30.6%);
- there is no evidence of wind or solar energy consumption.

# J. GUATEMALA

## 1. Renewable sources, rural energization and energy efficiency

Guatemala enjoys considerable renewable resources, which to date have not been fully taken advantage of. In fact, with over 5,000 MW of hydroelectric power potential, the country uses just 10% (540 MW) and with over 1,000 MW in potential geothermal energy, just 3% (29 MW) is used.

In 2000, Guatemala's Ministry of Energy and Mines (MEM) started a project for promoting renewable energy through actions to encourage its use in generating electric power, make investment easier, collect and offer basic information to investors.

The MEM also started an awareness campaign for the efficient and rational use of fuels and electric power; and a project to improve public lighting in rural areas project, which would install lamps in public spaces to rural area communities.

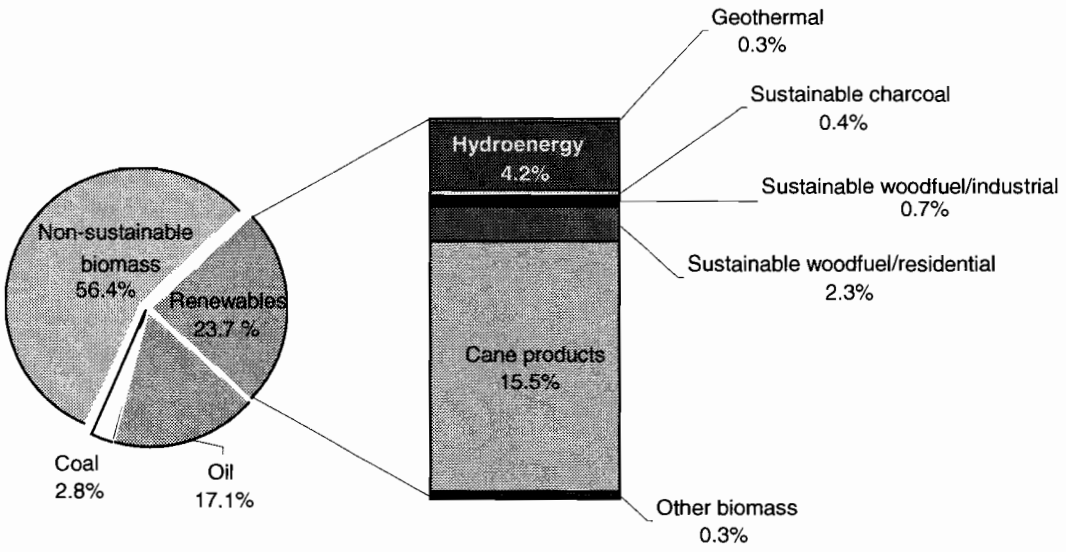
## 2. Study results

An analysis of Guatemala's energy balance sheet reveals that:

- Guatemala is an oil-importing country, since it produces enough to cover just 55% of domestic needs, so this source plays a sensitive role in the country's energy supply, accounting for one-sixth of the TPES. Imported coal plays a less important role;
- hydroenergy's contribution to primary supply is not significant and geothermal power is even less important;
- primary fuelwood accounts for over half of the TPES. Almost all goes to residential use (96%); just 2% to charcoal production and the remaining 2% goes to industrial use;
- the contribution from cane products accounts for a very significant percentage of the TPES;
- the "other primaries" post no consumption.

With this data and sectoral information from FAOSTAT, the percentage breakdown of the TPES in 2000 was as follows:

Figure III.10
**GUATEMALA: TOTAL PRIMARY ENERGY SUPPLY (TPES), 2000**




**Source**: Own calculations based on SIEE figures from the Latin American Energy Organization (OLADE); the Food and Agriculture Organization (FAO), FAOSTAT; and Argentina's energy balance sheet.

An analysis of this figure reveals that:

- the contribution from renewable energy sources is important but not dominant, as it accounts for just 23.7% of the TPES;
- within this percentage, the supply of hydroenergy (4.2%) is very small;
- the renewable non-woodfuel percentage, consisting of cane products and other biomass, accounts for 15.8%, representing a significant share of energy supply.

Guatemala proves to be one of the region's countries contributing the most forest energy to the TPES, reaching an accumulated percentage (renewable plus non-renewable) approaching 60%. In this sense, it is important to underline that according to official information from Guatemala's Ministry of Energy and Mines,[11] 96% of fuelwood consumed in rural and urban areas comes from woods suffering from deforestation and is therefore non-sustainable biomass.

This is behind the dominant role played by non-sustainable biomass in Guatemala's TPES and the huge difference between this figure and that of other countries in the Central American subregion (see, particularly, the cases of El Salvador and Nicaragua).

[11] Memorandum (Oficio) 447/2003, 8 July 2003, sent by the Guatemalan Minister of Energy and Mines, the engineer, Raul Archila.

# K. HAITI

## 1. The environment and rural energization

The enormously damaged environment in Haiti makes any effort to improve the quality of life very difficult. The reasons behind this damage are many; nonetheless, the main factor remains deforestation, which affects agriculture and hydroenergy production. The elements influencing the deforestation process include, in the first place, the growing demand for charcoal and fuelwood by urban and suburban sectors.

In the current context, to meet its obligation to provide universal access to electric power, the government is considering developing energy in three phases: legal reforms to the electrical sector, by creating an autonomous regulating body; modernization of the national electrical utility; and a programme for providing electricity to isolated towns and rural areas.

Replacing charcoal and fuelwood with other fuels remains a short and medium-term goal.

In terms of providing energy to widely spread out populations, the Haitian government's five-year economic and social development plan for 1999-2004 calls for building a health care centre and a primary school in every one of the country's rural communities, making the use of renewable energy in the rural electrification a priority within this programme that will cost almost US$ 6 million.

With support from the French Caribbean Institute a study of the country's wind potential is being carried out in the north, in order to prepare a master wind energy plan for this region.

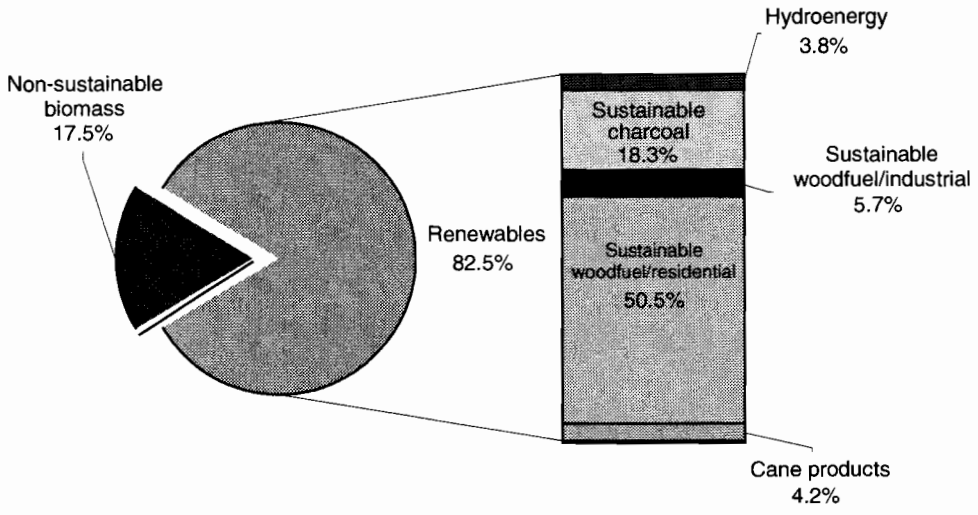
## 2. Study results

In 2000, the study of Haiti's energy system as represented by flows in its energy balance sheet reveals that:

- because it has no oil refineries, Haiti neither produces nor imports primary hydrocarbons;
- hydroenergy's contribution to primary supply not significant to primary supply;
- primary fuelwood (renewable and non-renewable) account for almost all of the TPES (92%); 28% goes to charcoal production; 11% is consumed in industry and more than 60% goes to residential use;
- the contribution from cane products is slight, but higher than hydroelectricity;
- no use of "other primaries" appears.

The percentage breakdown of the TPES in 2000 was as follows:

Figure III.11
**HAITI: TOTAL PRIMARY ENERGY SUPPLY (TPES), 2000**




**Source**: Own calculations based on SIEE figures from the Latin American Energy Organization (OLADE); the Food and Agriculture Organization (FAO), FAOSTAT; and Argentina's energy balance sheet.

An analysis of this figure reveals that:

- the contribution from the renewable energy sources group is very important, accounting for 82.5% of the TPES;
- there is a very small supply of hydroenergy (3.8%) and renewable non-fuelwood biomass (cane products, 4.2%);
- Haiti is the country in the region that contributes the most forest energy to the TPES, 74.5%; more than two-thirds of renewable fuelwood (68%) is used for household energy;
- new, renewable technologies such as wind, solar and geothermal energy, do not appear in the energy matrix.

# L. HONDURAS

## 1. Rural energization and renewable sources

In the past decade, in Honduras as in the rest of Latin America and the Caribbean, energy strategies and policies have been introduced to boost the electricity available in the respective interconnected systems, to (i) contribute to rural electrification and (ii) to facilitate industrial expansion by offering incentives to private investment.

These policies include incentives to generate electricity using renewable sources (such as the obligation on the part of the national electric power company to purchase energy). Projects that include carbon certificates in their financial costs analysis are also encouraged.

Norway has contributed over US$ 2.6 million to rural electrification in the country on the basis of an understanding with the Central American Bank for Economic Integration and the Government of Honduras. Investment in rural electrification is projected to serve more than 3,400 families in 160 rural communities.

The office for clean development and joint implementation mechanisms (*Mecanismos de Desarrollo Limpio e Implementación Conjunta de Honduras*, OICH), identified several projects in the energy sector, including the Honduras – 2000 wind generation project, to be located on Hula hill and in the mountains of Azacualpa and Izopo, with 80,750 kV wind power generators mounted on steel towers, to achieve a 60 MW capacity.

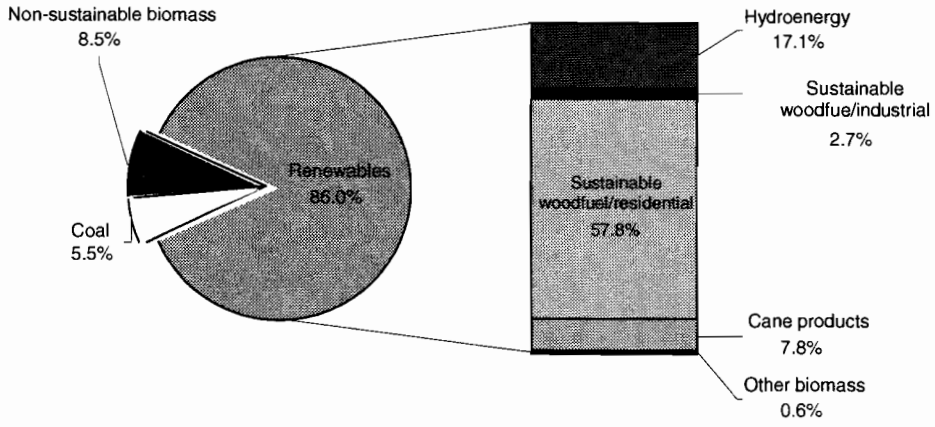
## 2. Study results

An analysis of Honduras' Total Primary Energy Supply and consumption reveals that:

- it neither produces nor imports primary hydrocarbons; coal, at just 134,000 tons is not very important either;
- hydroenergy's contribution to primary supply is significant, generating 2,825 GWh in 2000, that is almost one-sixth of the TPES;
- renewable and non-renewable primary fuelwood account for a very significant part of the TPES (69%). A small part of this goes to industry, with just 7%, while most goes to residential use, 93%;
- the contribution from cane products is significant but not too important;
- for now, "other primaries" do not appear and will not until the start-up of the wind project mentioned above.

The percentage breakdown of the TPES in 2000 was as follows:

Figure III.12
**HONDURAS: TOTAL PRIMARY ENERGY SUPPLY (TPES), 2000**




**Source**: Own calculations based on SIEE figures from the Latin American Energy Organization (OLADE); the Food and Agriculture Organization (FAO), FAOSTAT; and Argentina's energy balance sheet.

An analysis of this figure reveals that:

- the total contribution from renewable energy sources is one of the highest among the countries of Latin America, 86% of the TPES;
- of this percentage, the supply of hydroenergy (17.1%) and renewable non-fuelwood biomass (cane products and other biomass, 8.4%) are both significant;
- Honduras is the country in this region that contributes the most forest energy to the TPES, at 60.5%; almost all renewable fuelwood (95%) is used to meet family energy needs;
- the start-up of the wind power project on Hula hill will quickly push this contribution up to by several percentage points to reach a significant share of the country's TPES.

## M. MEXICO

### 1. Renewable sources

Starting in 2000, the development of some interesting electrical generating projects based on renewable energy sources moved ahead more quickly, among them the 20 MW Atexcaco hydroelectric project, in the State of Puebla; the 12 MW Los Azufres geothermal plan, in the State of Michoacan; and the 30 MW El Gallo hydroelectric power station in the State of Guerrero.

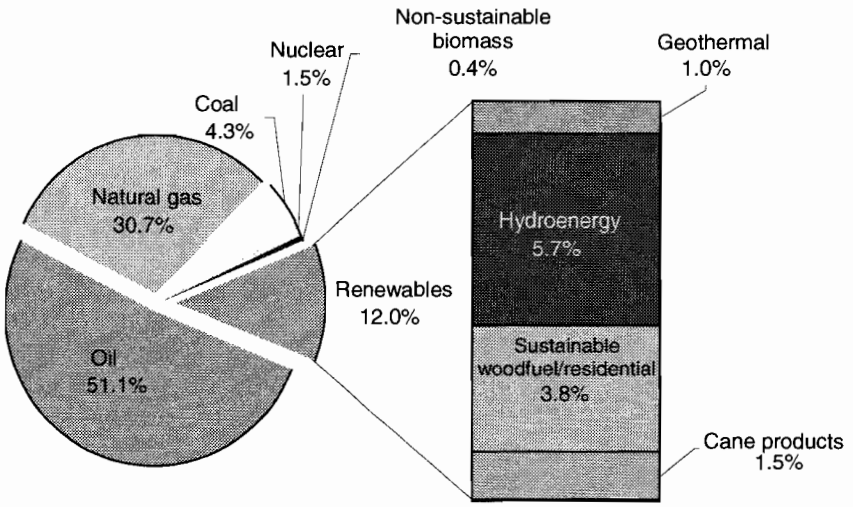
## 2. Study results

An analysis of Mexico's energy balance sheet reveals that:

- hydrocarbons (oil and natural gas) play a major role in the country's energy supply, accounting for over two-thirds of the TPES;
- coal and nuclear energy are not very significant, at no more than 6%;
- neither hydroelectric or geothermal power contributes significantly to primary supply;
- the supply of primary fuelwood accounts for a very small percentage of the TPES; it all goes to residential use;
- the contribution from cane products is just 14,000 tons or 1.5% of the TPES;
- the "other primaries" are practically nil in percentage terms, since existing biomass projects are very small in scale, the installed capacity of wind power is just 3 MW, and solar plant potential stands at less than 23 MW (WEC, 2000).

The percentage breakdown of the TPES in 2000, given Mexico's hydrocarbon use, follows:

Figure III.13
**MEXICO: TOTAL PRIMARY ENERGY SUPPLY (TPES), 2000**




**Source**: Own calculations based on SIEE figures from the Latin American Energy Organization (OLADE); the Food and Agriculture Organization (FAO), FAOSTAT; and Argentina's energy balance sheet.

It is apparent that:

- the total contribution from renewable sources is rather low, accounting for just 12% of the TPES;

- within renewable sources, the supply of hydroenergy is significant (5.7%), while geothermal (1.0%) and renewable non-fuelwood biomass (cane products 1.5%) are not very significant;
- the renewable part of fuelwood is rather low (3.8%), and goes to family consumption;
- percentage wise, the contribution from new, renewable technologies, such as solar and wind (this last has risen slightly) is virtually nil.

## N. NICARAGUA

### 1. Renewable sources and energy efficiency

In 1999, the national energy commission created the regulations for the electrical industry development fund (*Fondo para el Desarrollo de la Industria Eléctrica*, FODIEN), as a strategic element in deciding the amount to go to financing renewable energy projects.

Projects and specific studies include: a pilot programme and strategy to expand the supply of fuelwood on Nicaragua's Pacific coast; the design of a pilot programme to use compact florescent lamps to reduce electrical consumption in residential sector lighting; the geothermal master plan; improvements to energy efficiency study and analytical capacity in industry and commerce; feasibility studies for small hydroelectric plants in Jinotega, Matagalpa and Boaco; an evaluation of wind power potential; and pilot rural electrification projects.

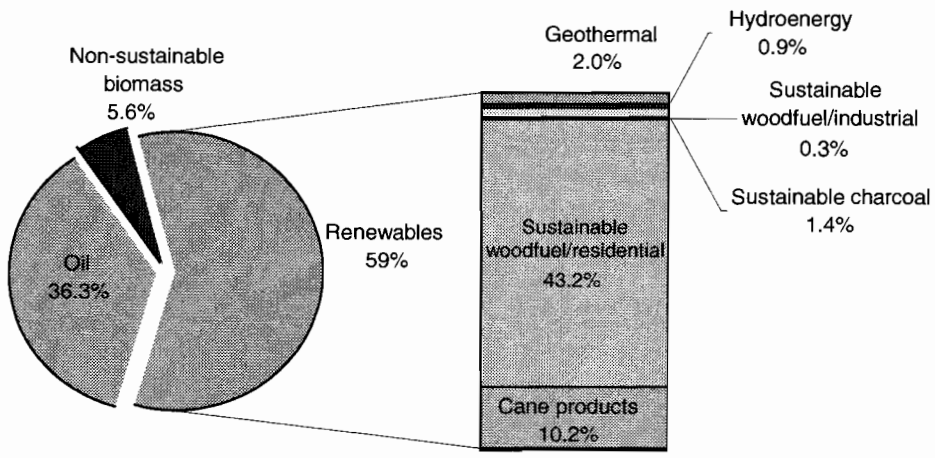
### 2. Study results

An analysis of Nicaragua's energy balance sheet reveals:

- imported oil plays a significant role in the country's energy supply, accounting for more than one-third of the TPES;
- hydroenergy's contribution to primary supply is minimal, as is that of geothermal energy;
- primary fuelwood represents almost half of the TPES; just 4% goes to charcoal production, 95% goes to residential use, and just 1% to industry;
- the contribution from cane products is substantial, perhaps among the largest in Central America;
- despite negotiations around significant wind power projects some years back, to date these do not appear among "other primaries".

Thus, the percentage breakdown of the TPES in 2000 is presented in the following figure:

Figure III.14
**NICARAGUA: TOTAL PRIMARY ENERGY SUPPLY (TPES), 2000**




**Source**: Own calculations based on SIEE figures from the Latin American Energy Organization (OLADE); the Food and Agriculture Organization (FAO), FAOSTAT; and Argentina's energy balance sheet.

This figure reveals that:

- the contribution from renewable energy sources is very important, accounting for 59% of the TPES;
- the shares for hydroenergy (0.9%) and geothermal energy (2%) are not very important;
- renewable non-woodfuel biomass (cane products) is very significant, standing at 10.2% of the TPES;
- Honduras is one of the region's countries contributing the most forest energy to the TPES, at 45%; almost all renewable fuelwood (96%) goes to personal or residential consumption;
- the contribution from new, renewable technologies is virtually nil; wind power potential is interesting, but remains unexploited.

## O. PANAMA

### 1. Study results

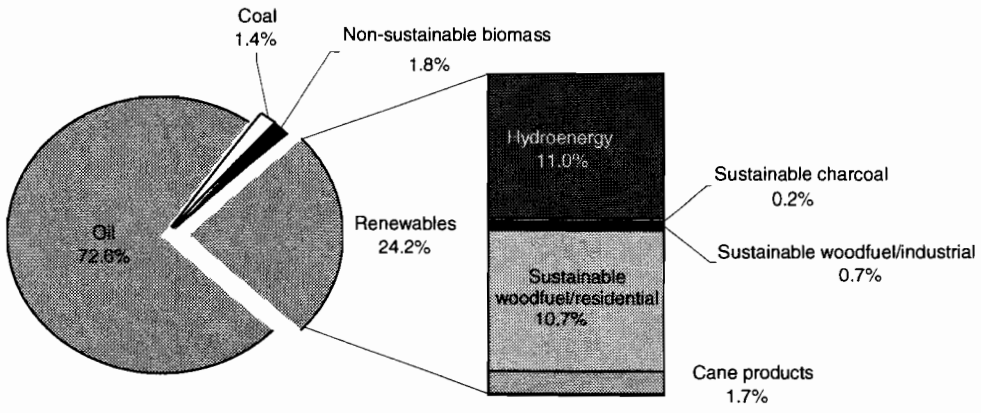
Panama's energy balance sheet reveals that:

- imported oil plays a leading role in the country's energy supply, accounting for more than el 70% of the TPES;

- imported coal (60,000 tons) accounts for a small fraction of the TPES, just 1.4%;
- hydroenergy's contribution to primary supply is significant;
- primary fuelwood plays a role similar to that of hydroenergy in Panama's TPES and goes mainly to the residential sector, 89%, followed by industry with 9%, and industry 2%;
- the contribution from cane products is very slight, and "other primaries" do not appear in the TPES.

The percentage breakdown of the TPES in 2000 was as follows:

Figure III.15
**PANAMA: TOTAL PRIMARY ENERGY SUPPLY (TPES), 2000**




**Source**: Own calculations based on SIEE figures from the Latin American Energy Organization (OLADE); the Food and Agriculture Organization (FAO), FAOSTAT; and Argentina's energy balance sheet.

An analysis of this figure reveals that:

- the total contribution from renewable energy sources is about one-quarter of the TPES;
- the most important fraction of renewable supply is hydroenergy (11.0%), while cane products are less important (1.7%);
- the renewable part of fuelwood goes mainly to residential use (10.7% of the TPES), while 0.2% goes to charcoal production and 0.7% to industrial use;
- there is no noticeable use of new renewable technologies, although the country has considerable potential for wind and geothermal energy.

# P. PARAGUAY

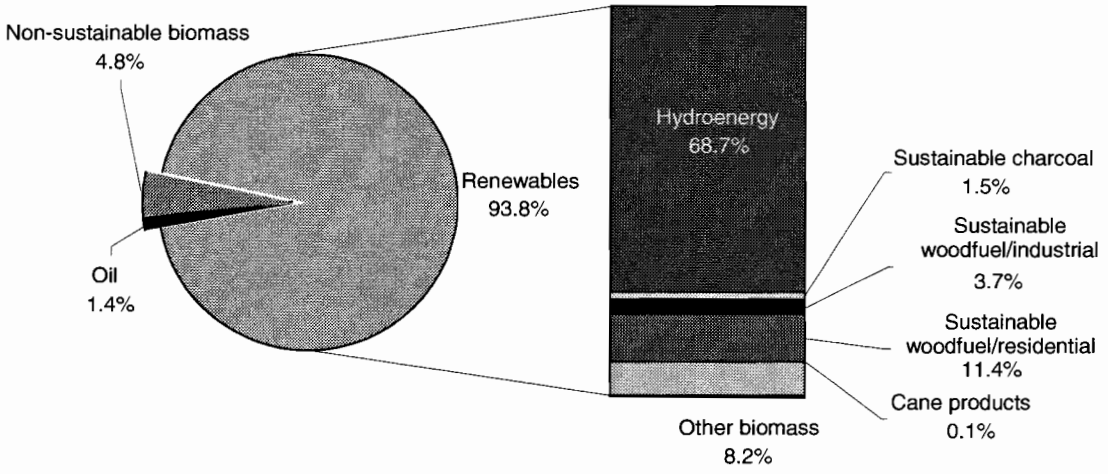
## 1. Study results

An analysis of total primary energy consumption and supply reveals that:

- imported oil plays a very small role in the country's energy supply;
- hydroenergy's contribution to primary supply clearly prevails in Paraguay's TPES (more than 60,000 GWh, for a country with just 5.6 million inhabitants);
- primary fuelwood accounts for a small part of the TPES; 10% goes to charcoal production, 31% to industry and almost 60% to residential use;
- the contribution from cane products is almost nil;
- the "other primaries" are significant and represented mainly by agricultural residues (agrofuels).

The percentage breakdown of the TPES in 2000 follows:

Figure III.16
**PARAGUAY: TOTAL PRIMARY ENERGY SUPPLY (TPES), 2000**




**Source**: Own calculations based on SIEE figures from the Latin American Energy Organization (OLADE); the Food and Agriculture Organization (FAO), FAOSTAT; and Argentina's energy balance sheet.

It is apparent that:

- renewable energy sources predominate, accounting for 93.8% of the TPES;
- hydroenergy (68.7%) is also clearly dominant, in fact the highest in Latin America;
- cane products and other biomass account for more than 8% of the TPES;
- renewable biomass is significant, at 6.6%; of this percentage, 1.5% goes to charcoal, 3.7% to industrial, and 11.4% to family energy needs;

- no contribution from renewable technologies, such as wind, solar and geothermal power, is apparent.

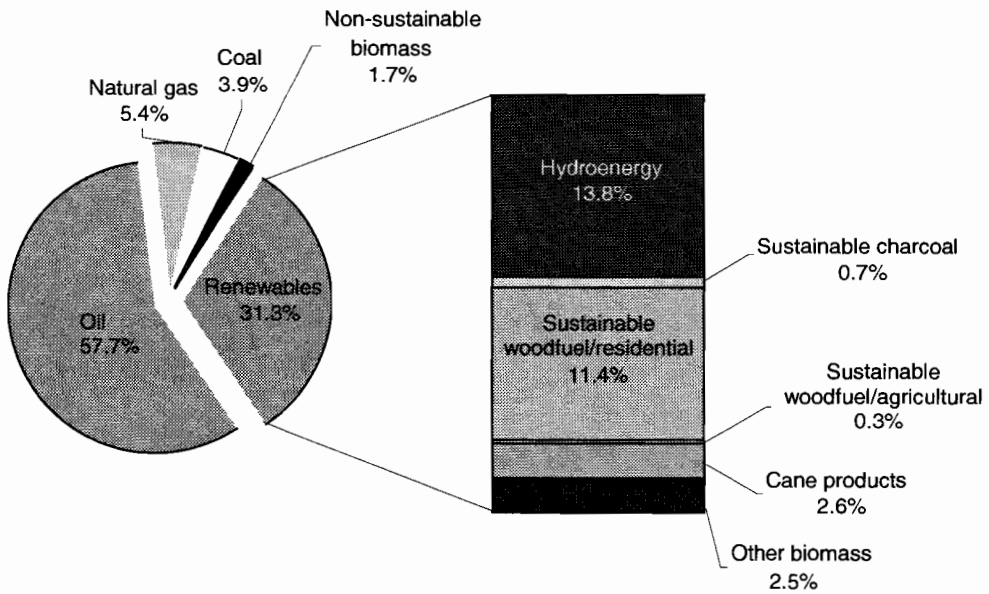
## Q. PERU

An analysis of Peru's energy balance sheet for Total Primary Energy Supply and consumption reveals that:

- imported and locally produced oil plays a major and dominant role in the country's primary energy supply, accounting for almost two-thirds of the TPES;
- altogether, natural gas and coal account for less than 10% and are therefore not decisive;
- hydroenergy's contribution to primary supply is significant. In 2000, it amounted to over 16,000 GWh, or 14% of total primary supply;
- primary fuelwood does not hold a significant share of the TPES. It is primarily consumed in the residential sector (90%), 7% goes to producing charcoal, and just 3% goes to agricultural usage. Industrial use is virtually nil;
- the contribution from cane products is very low and "other primaries" mainly reflect consumption of agricultural residues (agrofuels).

The percentage breakdown of the TPES in 2000 follows:

Figure III.17
**PERU: TOTAL PRIMARY ENERGY SUPPLY (TPES), 2000**




**Source**: Own calculations based on SIEE figures from the Latin American Energy Organization (OLADE); the Food and Agriculture Organization (FAO), FAOSTAT; and Argentina's energy balance sheet.

An analysis of this figure reveals that:

- the contribution from all renewable energy sources is noteworthy, accounting for one-third of the TPES;
- within this percentage, hydroenergy is the main contributor, with 13.8% accounting for more than half the contribution from the set of renewables;
- the other half of the total contribution from renewables consists of renewable non-woodfuel biomass, with 5.1%, and renewable forest energy, with 12.2%. The final destination of the latter breaks down to 0.7% for charcoal, 11.2% for residential, and 0.3% for agricultural use;
- new, renewable technologies consisting of wind, solar and geothermal energy, make no significant contribution, despite the fact that Peru has important geothermal production potential, particularly in the south.

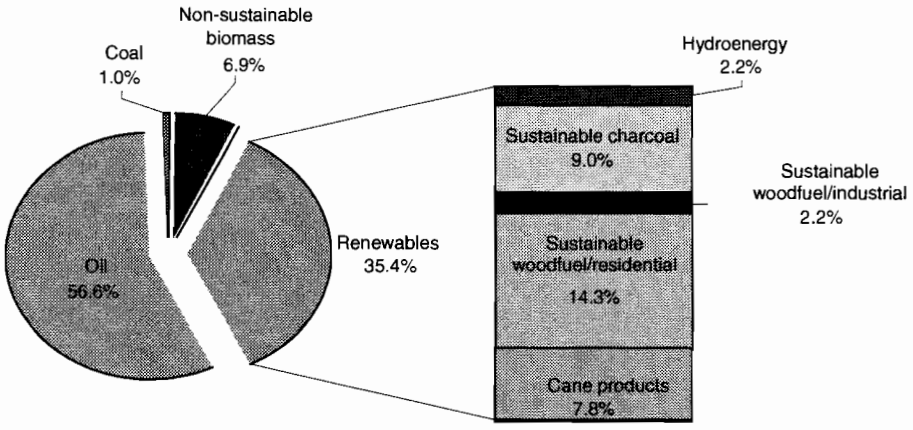
## R. THE DOMINICAN REPUBLIC

The Dominican Republic's total primary energy consumption and supply in 2000 reveals that:

- imported oil is the country's main source of energy, accounting for more than half of the TPES;
- coal's importance is slight in percentage terms, as also occurs with hydroenergy;
- primary fuelwood reaches over three million tons, one-fourth of the TPES. 39% goes to intermediate consumption, that is charcoal production, 12% is consumed in industry, and almost 50% goes to residential use;
- the contribution from cane products is substantial, accounting for almost 2 million BEP in 2000;
- no supply of "other primaries" has been posted.

The percentage breakdown of the TPES in 2000 was:

Figure III.18
**DOMINICAN REPUBLIC: TOTAL PRIMARY ENERGY SUPPLY (TPES), 2000**




**Source**: Own calculations based on SIEE figures from the Latin American Energy Organization (OLADE); the Food and Agriculture Organization (FAO), FAOSTAT; and Argentina's energy balance sheet.

This figure suggests that:

- more than one-third of the TPES comes from renewable sources, so their contribution is significant;
- the supply of renewable non-woodfuel biomass is small, consisting essentially of cane products, with 7.8%; while hydroenergy contributes even less at just 2.2%;
- renewable forest energy is important, representing 25.5% of the TPES. Of this percentage, more than half goes to residential use (14.3%); 9.0% for charcoal production; and the rest, 2.2%, to the industrial sector;
- no use of new renewable technologies, such as wind, solar and geothermal power, is apparent.

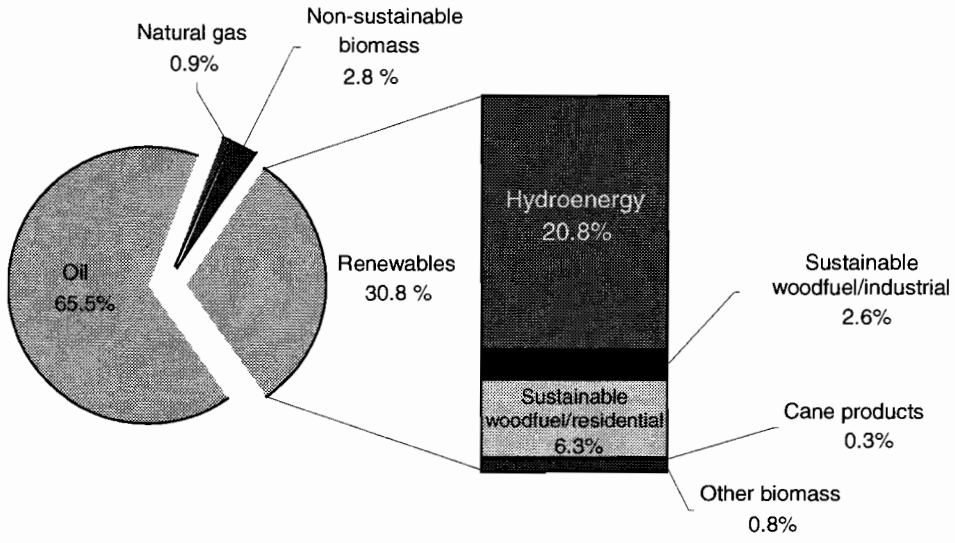
## S. URUGUAY

The breakdown of Uruguay's energy balance sheet reveals that:

- imported oil predominates, with almost two-thirds of the TPES: it therefore plays a major role in Uruguay's energy supply;
- hydroenergy is the second most important contributor to primary supply, generating over 8,000 GWh or one-fifth of primary supply;
- primary fuelwood is not a significant source of energy. However, more than three-quarters goes to residential consumption (78%); while the rest, 22%, goes to industry;
- the contribution from cane products is marginal, as is that of "other primaries".

The percentage breakdown of the TPES in 2000 follows:

Figure III.19
**URUGUAY: TOTAL PRIMARY ENERGY SUPPLY (TPES), 2000**




**Source**: Own calculations based on SIEE figures from the Latin American Energy Organization (OLADE); the Food and Agriculture Organization (FAO), FAOSTAT; and Argentina's energy balance sheet.

An analysis of this figure reveals that:

- the contribution from renewable energy sources as a whole is significant, approaching one-third of the TPES (30.8%);
- the dominance of hydroenergy (20.8% of the TPES) is clear;
- in order of importance, hydroenergy is followed by renewable forest energy, mainly for family consumption (6.3%), and marginal for industrial use (2.6%). Fuelwood's use to produce charcoal is negligible (< 0.1%);
- the importance of renewable non-woodfuel biomass (cane products and other biomass) is slight, at just over 1%;
- new, renewable technologies do not appear, despite the fact that Uruguay makes considerable use of wind energy (mainly in providing and pumping water in rural areas).

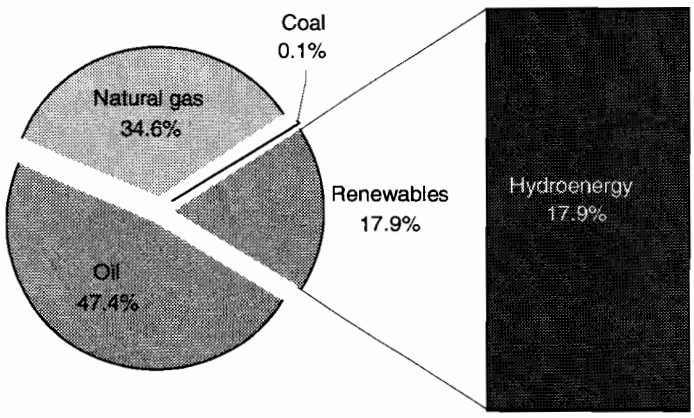
# T. VENEZUELA

Venezuela's energy balance sheet clearly reflects the fact that it produces hydrocarbons and is a net oil exporter. Its main characteristics include:

- the country's primary energy supply is clearly dominated by hydrocarbons, with oil and natural gas together accounting for more than 80% of the TPES;
- hydroenergy is the only renewable source available in the country and accounts for the remainder;
- primary fuelwood, cane products and "other primaries" contribute extremely small amounts and therefore cannot be estimated in percentage terms. Of the 42,000 tons of fuelwood, 71% goes to industry and 29% to domestic use.

Based on this information and examining FAOSTAT sectoral figures, the percentage breakdown of the TPES in 2000 is as follows:

Figure III.20
**VENEZUELA: TOTAL PRIMARY ENERGY SUPPLY (TPES), 2000**




**Source**: Own calculations based on SIEE figures from the Latin American Energy Organization (OLADE); the Food and Agriculture Organization (FAO), FAOSTAT; and Argentina's energy balance sheet.

The figure clearly indicates that the contribution from renewable energy sources as a whole is limited to hydroenergy, which accounts for 17.9% of the TPES, while the contribution from other renewable sources is virtually nil.

# IV. SUBREGIONAL PANORAMA

The purpose of examining the share of renewable energy sources per subregion is to identify their potential in each subregion or group of countries, which could serve as the basis for a viable increase in their share of total national and regional energy matrices.

In this sense, along with the efforts of each country, subregional results could also be achieved through initiatives such as: technological exchange; cooperation to assist isolated communities; grouping energy matrices to achieve minimum targets; and the development of accounting methods and mechanisms for exchanging renewable energy certifications, among others.

This way, instead of castigating countries with less favourable natural conditions in terms of energy sustainability, subregions could use the Latin American Initiative as a guideline to promote the growing participation of renewable sources at the regional and global levels.

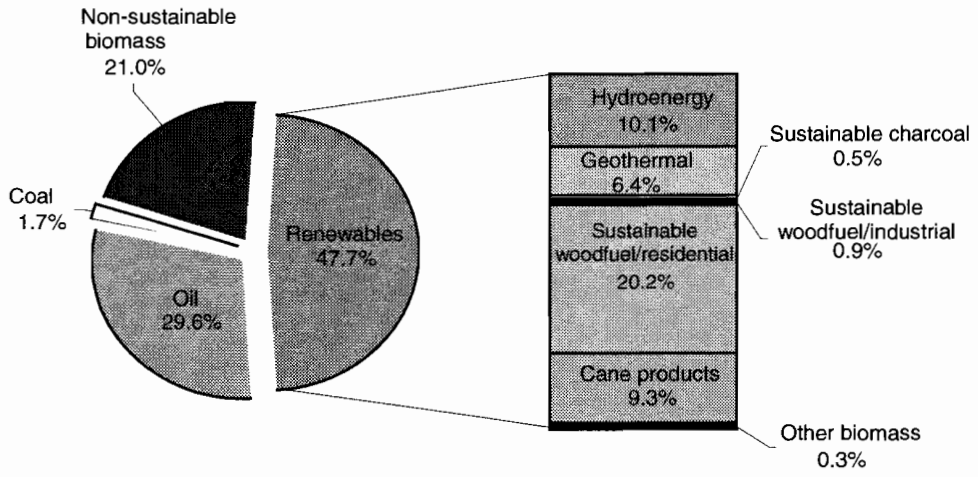
## A. CENTRAL AMERICA

In the Central American subregion, the contribution from renewables to Total Primary Energy Supply (TPES) is very relevant, approaching 50%.

Although oil's share of the TPES does not exceed 30%, total dependency on hydrocarbons is nonetheless significant.

Similarly, the share held by unsustainable biomass also stands out, raising serious concerns about the efficiency and sustainability of woodfuel use in the region's countries. This should encourage addition research projects to explore this subject, which could in turn become candidates for international cooperation.

Figure IV.1
**CENTRAL AMERICA: TOTAL PRIMARY ENERGY SUPPLY (TPES), 2000**




**Source**: Own calculations based on SIEE figures from the Latin American Energy Organization (OLADE); the Food and Agriculture Organization (FAO), FAOSTAT; and Argentina's Energy Balance Sheet.

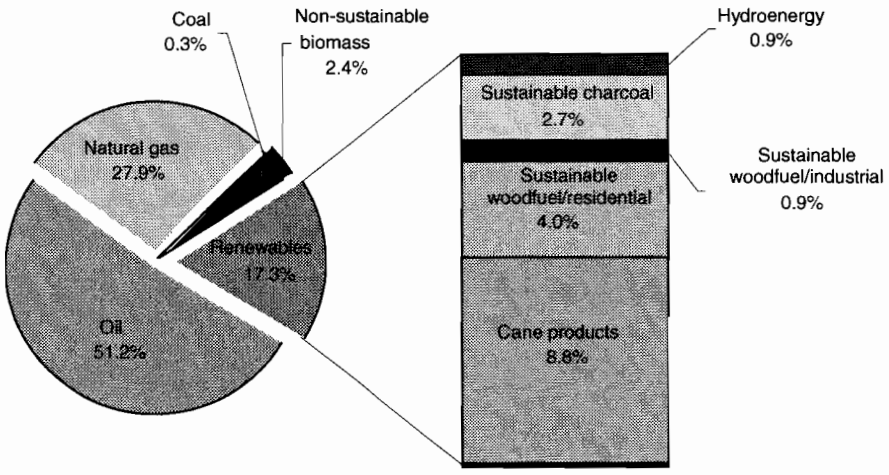
## B. CARIBBEAN

An analysis of the TPES in the Caribbean region, that is, for the nine countries included in this study,[12] reveals their heavy dependency on hydrocarbons, which stands at almost 80%. Renewables, which account for 17%, are basically composed of woodfuel and woodfuel products, with 7.6%, cane products with almost 9%, and hydroenergy, which is remarkably marginal, at less than 1%.

These comments are not very relevant, however, given the enormous range of energy characteristics in terms of both supply and demand in each of the nine countries included.

[12] Barbados, Cuba, Grenada, Guyana, Haiti, Jamaica, the Dominican Republic, Suriname and Trinidad and Tobago.

Figure IV.2
**CARIBBEAN: TOTAL PRIMARY ENERGY SUPPLY (TPES), 2000**



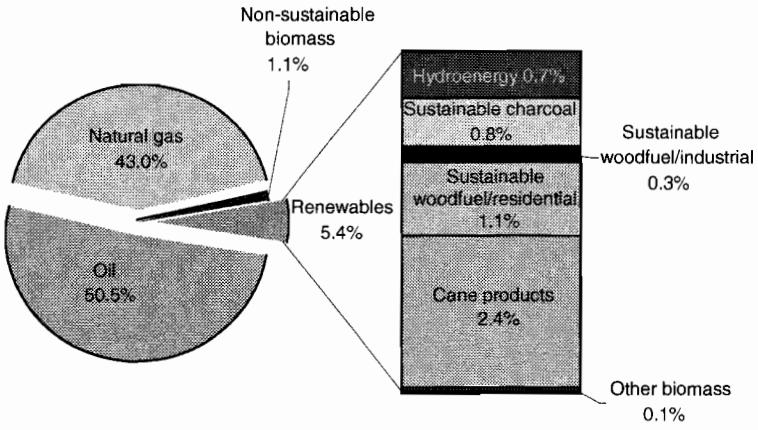

**Source**: Own calculations based on SIEE figures from the Latin American Energy Organization (OLADE); the Food and Agriculture Organization (FAO), FAOSTAT; and Argentina's Energy Balance Sheet.

When supply and consumption are analysed separately, two subregions prove much more relevant: (1) the countries in the Lesser Antilles, along with Jamaica, Suriname and Guyana; and (2) the countries belonging to the Greater Antilles (Haiti, Cuba and the Dominican Republic).

## 1. Caribbean Subregion 1

This region's countries' hydrocarbon dependency (93.5%) is among the most important, compared to other subregions within Latin America and the Caribbean. In contrast, the contribution from renewables is very small (5.4%), in fact, the lowest in all of Latin America and the Caribbean. Among the renewables, only cane products play a significant role.

Figure IV.3
**CARIBBEAN/SUBREGION 1: TOTAL PRIMARY ENERGY SUPPLY (TPES), 2000**
*(Barbados, Surinam, Guyana, Grenada, Trinidad and Tobago, Jamaica)*

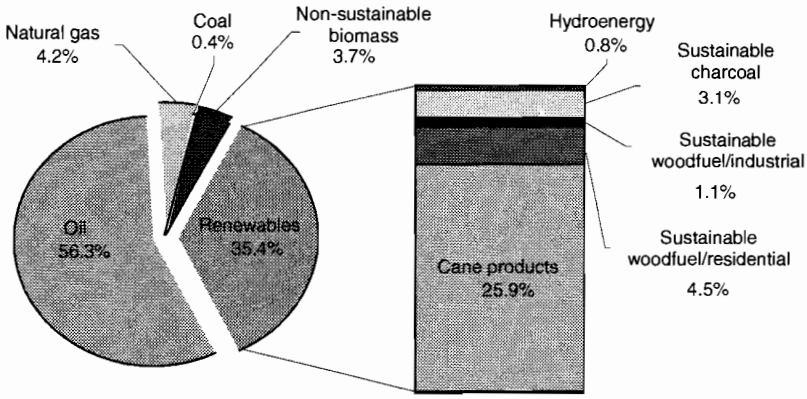



**Source**: Own calculations based on SIEE figures from the Latin American Energy Organization (OLADE); the Food and Agriculture Organization (FAO), FAOSTAT; and Argentina's Energy Balance Sheet.

## 2. Caribbean Subregion 2

Conditions are very different from the above in the subregion formed by Haiti, Cuba and the Dominican Republic.

Figure IV.4
**CARIBBEAN/SUBREGION 2: TOTAL PRIMARY ENERGY SUPPLY (TPES), 2000**
*(Cuba, Dominican Republic, Haiti)*



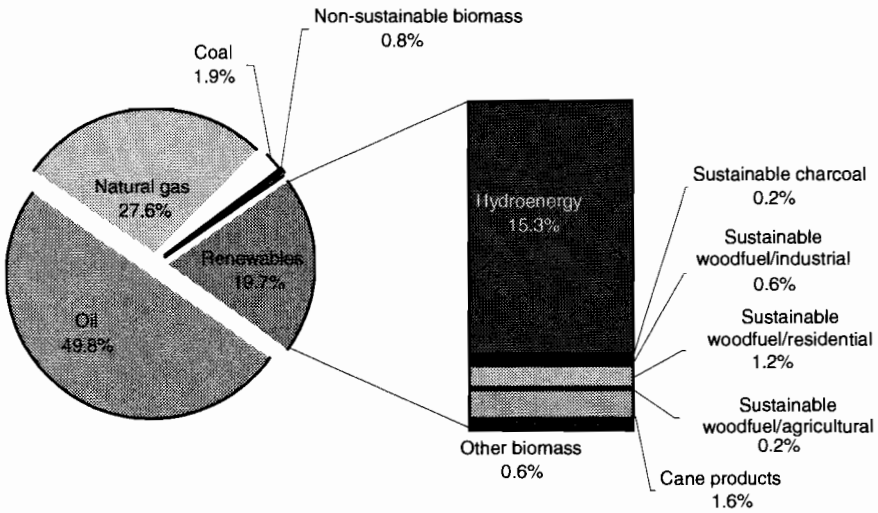

**Source**: Own calculations based on SIEE figures from the Latin American Energy Organization (OLADE); the Food and Agriculture Organization (FAO), FAOSTAT; and Argentina's Energy Balance Sheet.

The contribution from renewables is rather significant, accounting for more than one-third of the TPES. Of this amount, cane products account for over 70%, while woodfuel and its derivatives account for another 30% of the total renewable portion. Hydroenergy is very slight, less than 1%.

## C. ANDEAN COMMUNITY OF NATIONS

For the countries of the Andean Community of Nations (Venezuela, Colombia, Ecuador, Peru and Bolivia), hydrocarbon dependency, at almost 80%, is very significant.

Figure IV.5
**ANDEAN COMMUNITY: TOTAL PRIMARY ENERGY SUPPLY (TPES), 2000**




**Source**: Own calculations based on SIEE figures from the Latin American Energy Organization (OLADE); the Food and Agriculture Organization (FAO), FAOSTAT; and Argentina's Energy Balance Sheet.

Renewables account for less than 20% of supply, with hydroenergy playing a major role, basically due to generation from large hydroelectric power stations.

Given the enormous potential of this region's countries for different renewable resources associated with modern technology, such as geothermal power, wind energy, small and mini-hydraulic generating stations, the Andean Community has significant room to improve. In particular, the international carbon credit market could play a decisive role in developing new projects that apply these new technologies.

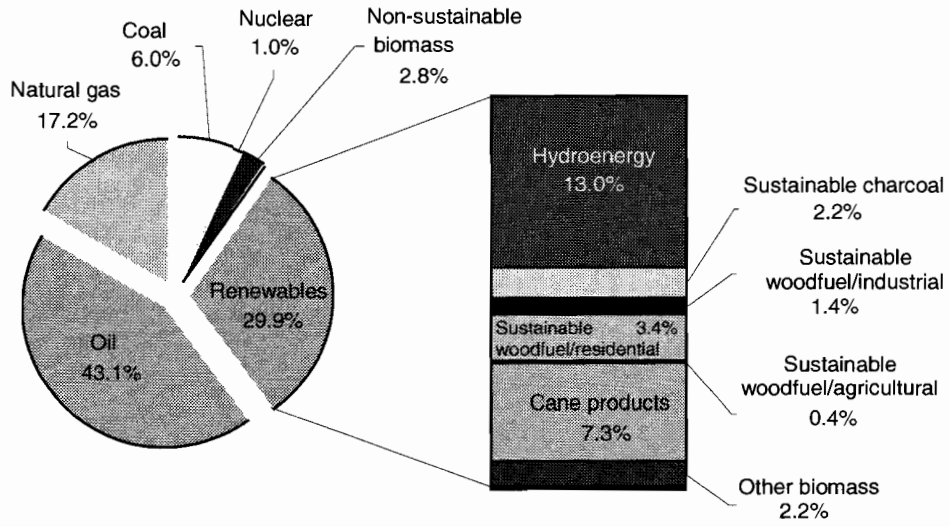
## D. MERCOSUR AND CHILE

Depending on the perspective, conditions in this bloc of countries look very similar to or rather different from those prevailing in the Andean Community.

They are similar in the sense that: (i) there is heavy dependency on fossil fuels; (ii) renewable energy sources account for less than 30%, and (iii) the contribution from hydroelectric generation by large power stations is significant. Another similarity with the Andean Community countries is that the prospects for modern renewable technologies, especially geothermal power, wind energy, mini- and small hydroelectric generating stations look very promising, although that they have not yet been developed as they could be.

On the other hand, they are different in terms of their endowment of fossil resources. Expanded Mercosur, despite the weight of hydrocarbons within the TPES, presents a significant deficit in the hydrocarbon trade balance: in 2000, this reached 257 million oil-equivalent barrels, that is 22.3% of fossil energy produced in this subregion.

Figure IV.6
**MERCOSUR & CHILE: TOTAL PRIMARY ENERGY SUPPLY (TPES), 2000**




**Source**: Own calculations based on SIEE figures from the Latin American Energy Organization (OLADE); the Food and Agriculture Organization (FAO), FAOSTAT; and Argentina's Energy Balance Sheet.

# V. COMPARATIVE REGIONAL OUTLOOK: ENERGY AND SUSTAINABILITY INDICES

Table 1 provides a summary of the energy and non-energy variables for building the indices presented below. Based on this information, national performance indices can be developed for the energy sector in 2000, which are directly associated with the role of renewable energies and, moreover, take into account local and global environmental issues, associated with carbon dioxide ($CO_2$).

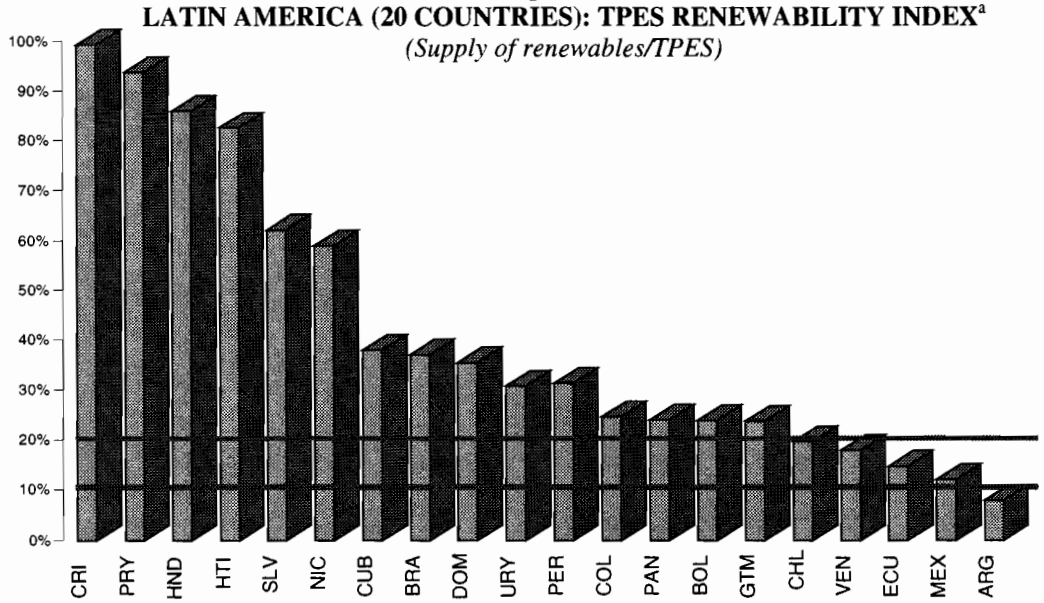
## 1. TPES Renewability Index (RI)

This index captures the relationship between total renewable energy over Total Primary Energy Supply (TPES) in 2000.

It therefore provides quantitative information about the level of renewable sources' participation in both domestic energy supply going to final consumption sectors and intermediate sources going to transformation centres within a country.

It should be remembered that the target is to ensure that by 2010, renewable sources account for 10% of primary energy supply in the Latin American and Caribbean proposal presented to the Sustainable Development Summit in Johannesburg. As a result, a high index means that the country is over quota and has thus met the target that this initiative proposes for Latin America.

Figure V.1
**LATIN AMERICA (20 COUNTRIES): TPES RENEWABILITY INDEX[a]**
*(Supply of renewables/TPES)*




**Source**: Own calculations based on SIEE figures from the Latin American Energy Organization (OLADE); the Food and Agriculture Organization (FAO), FAOSTAT.

[a] Total Primary Energy Supply.

Table 1

**LATIN AMERICA (20 COUNTRIES): INDICATORS RELATED TO TOTAL ENERGY SUPPLY AND CONSUMPTION, 2000**

| | | TOTAL ENERGY SUPPLY (BY SECTOR), 2000 | | | | | | ENERGY CONSUMPTION, 2000 | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Population | Total Renewable Energy Supply | Total Woodfuel Energy Supply | Total Combined Secondary Fuel Energy Supply | Total Oil Energy Supply | Total Hydro Energy Supply | $CO_2$ from Electricity | Per capita Consumption | Woodfuel Consumption | Combined Secondary Fuel Consumption | Total Consumption | Electricity Generation | TPES | Total $CO_2$ |
| | Population in 2000 (thousands) | Total renewable energy (toeb) | Total woodfuel (toeb) | Secondary hydrocarbons (liquid gas from oil), kerosene, diesel (toeb) | Oil (toeb) | Hydroenergy (toeb) | Electric power generation emissions (thousands of tons of $CO_2$) | Per capita consumption of electricity | Woodfuel consumption (toeb) | Secondary hydrocarbon consumption (toeb) | Total final consumption (toeb) | Electric power production (GWh) | Total primary energy supply (toeb) | Total emissions (tons of $CO_2$) |
| ARG | 37 500 | 37 594 | 4 350 | 103 991 | 192 800 | 17 588 | 21 037 | 2 033 | 1 953 | 25 023 | 324 902 | 90 006 | 481 199 | 135 100 |
| BOL | 8 516 | 8 657 | 2 457 | 9 025 | 14 890 | 4 531 | 1 786 | 407 | 2 457 | 4 650 | 19 285 | 3 972 | 36 224 | 7 117 |
| BRA | 172 000 | 515 087 | 154 790 | 302 898 | 584 030 | 190 602 | 27 087 | 1 724 | 98 361 | 127 172 | 1 074 572 | 327 241 | 1 271 142 | 296 897 |
| CHL | 15 100 | 36 229 | 30 655 | 46 610 | 75 886 | 6 287 | 11 692 | 2 599 | 28 266 | 42 557 | 143 595 | 42 531 | 184 991 | 54 017 |
| COL | 43 000 | 61 608 | 19 667 | 32 689 | 109 797 | 23 673 | 7 028 | 817 | 16 131 | 23 976 | 165 684 | 43 462 | 236 407 | 55 189 |
| CRI | 3 940 | 9 983 | 418 | 5 917 | 0 | 4 940 | 371 | 1 533 | 418 | 2 322 | 17 014 | 6 940 | 10 002 | 5 282 |
| CUB | 11 200 | 21 657 | 2 109 | 17 383 | 32 074 | 68 | 849 | 1 060 | 1 505 | 3 414 | 60 861 | 15 301 | 57 144 | 26 583 |
| ECU | 12 500 | 10 263 | 3 011 | 22 162 | 61 075 | 5 238 | 3 001 | 660 | 3 012 | 6 673 | 45 973 | 11 049 | 73 598 | 18 214 |
| SLV | 6 390 | 14 349 | 8 168 | 6 499 | 7 052 | 943 | 1 436 | 580 | 8 011 | 10 027 | 21 124 | 3 877 | 21 420 | 5 670 |
| GTM | 11 700 | 9 247 | 23 317 | 9 847 | 6 659 | 1 652 | 2 521 | 2 520 | 23 190 | 28 231 | 46 208 | 5 856 | 39 017 | 9 531 |
| HTI | 8 510 | 11 369 | 10 462 | 2 616 | 0 | 432 | 193 | 34 | 7 487 | 7 714 | 12 559 | 604 | 11 371 | 1 494 |
| HND | 6 650 | 10 718 | 8 606 | 5 080 | 0 | 2 135 | 1 220 | 506 | 8 607 | 10 333 | 19 971 | 3 917 | 12 463 | 4 601 |
| MEX | 100 000 | 128 150 | 43 720 | 208 952 | 526 708 | 58 910 | 111 493 | 1 574 | 43 721 | 156 788 | 703 210 | 197 235 | 975 719 | 353 358 |
| NIC | 5 200 | 10 678 | 8 468 | 3 439 | 6 086 | 154 | 1 499 | 310 | 8 054 | 9 863 | 15 281 | 2 472 | 16 766 | 3 578 |
| PAN | 2 800 | 5 761 | 2 953 | 4 951 | 16 117 | 2 433 | 1 080 | 1 370 | 2 886 | 5 336 | 13 727 | 5 124 | 22 195 | 4 805 |
| PRY | 5 600 | 53 421 | 11 671 | 6 071 | 740 | 37 225 | 0 | 790 | 10 431 | 11 221 | 26 415 | 45 310 | 54 163 | 3 421 |
| PER | 26 000 | 29 908 | 12 817 | 30 002 | 52 368 | 12 529 | 2 438 | 700 | 12 112 | 15 250 | 80 026 | 20 785 | 90 740 | 26 614 |
| DOM | 8 600 | 10 822 | 8 254 | 22 888 | 14 445 | 573 | 6 463 | 800 | 5 043 | 12 306 | 39 079 | 10 307 | 25 528 | 16 941 |
| URY | 3 340 | 7 346 | 2 767 | 6 617 | 15 627 | 4 959 | 25 | 1 910 | 2 750 | 4 685 | 18 067 | 9 250 | 23 851 | 5 237 |
| VEN | 24 600 | 145 552 | 220 | 53 395 | 385 310 | 145 317 | 24 694 | 2 600 | 31 | 27 325 | 233 838 | 89 973 | 813 240 | 127 619 |

T(P)ES = TOTAL (PRIMARY) ENERGY SUPPLY

**Source**: Own calculations based on SIEE figures from the Latin American Energy Organization (OLADE); the Food and Agriculture Organization (FAO), FAOSTAT; and Argentina's Energy Balance Sheet.

Figure V.1 reveals that:

- The countries that are below the 10% line or close to this percentage must make a significant effort to meet the target for renewables' share of the TPES (for example, the 10% goal set for 2010, proposed by the Initiative). Argentina is, therefore, one of the countries with the most problems in this sense.

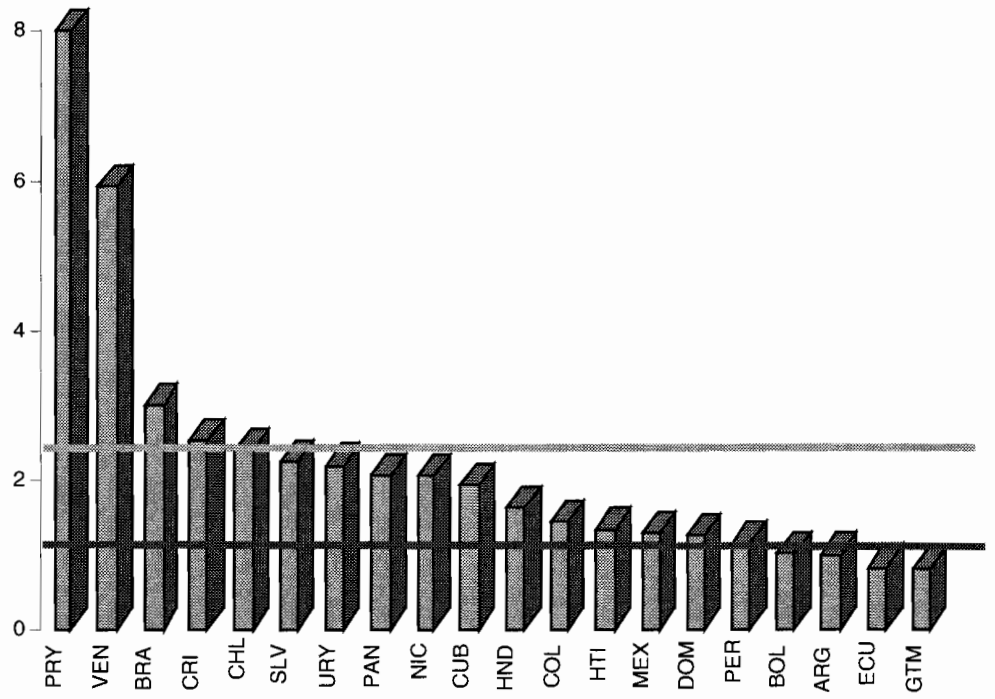
- Those countries within the 10% to 20% range, as is the case with Chile, Ecuador, Mexico and Venezuela should act decisively in the sense of both policy and renewable project promotion if they wish to maintain renewables' current share of the TPES. A third group of countries facing less risk includes Bolivia, Colombia, Guatemala and Panama, which, if current trends of non-renewable fossil fuel penetration continue in the medium term, might not be able to meet the target set by the Initiative.

## 2. Per Capita Renewability Index (CRI)

This indicator expresses the relationship between the primary energy supply from all renewable sources and the country's population. A high index means that in qualitative terms there is more "commitment" to energy sustainability, and therefore to energy from renewable sources per capita in each country.

If the country's CRI is low and population growth high, there is some risk that the country will not meet the target for renewables' share by 2010 unless an effort is made to change the type of energy supplied for consumption (fewer hydrocarbons and more renewables). But this index is also more important for the future, given that if the growth rate for renewable energy is lower than that of the population, the goal of renewables accounting for a 10% share of the TPES may not be achieved or maintained in the medium term.

Figure V.2
**LATIN AMERICA (20 COUNTRIES): PER CAPITA RENEWABILITY INDEX**
*(In thousands of oil-equivalent barrels/per capita)*




**Source**: Own calculations based on SIEE figures from the Latin American Energy Organization (OLADE); the Food and Agriculture Organization (FAO), FAOSTAT.

Figure V.2 reveals the following characteristics:

- Paraguay has the highest index, mostly reflecting the enormous supply of hydroelectric power available to the country, which is not apparent in the case of other technologies or renewable sources other than woodfuel. Something very similar occurs with Venezuela.
- Costa Rica posts a high index, which is positive in terms of sustainable development. In this case, the high value reached by the index reflects the substantial contribution, within the TPES, of a variety of renewable energy sources, among them geothermal power, agrofuels, forest energy, hydroelectricity.

- Chile and Brazil post high values, reflecting mainly the strong influence of woodfuel and hydroenergy, but also the absence of other renewable technologies.

- Once again, the oil- and gas-producing countries (Mexico, Argentina, Ecuador, Bolivia, Peru) post low indices, that is they reflect the lack of a long-term orientation toward the development of sustainable energy. Guatemala has also posted very low values, in this case reflecting a very large percentage of unsustainable biomass (96%) used in the country, according to official information from the Ministry of Energy and Mines (see point IV.10).

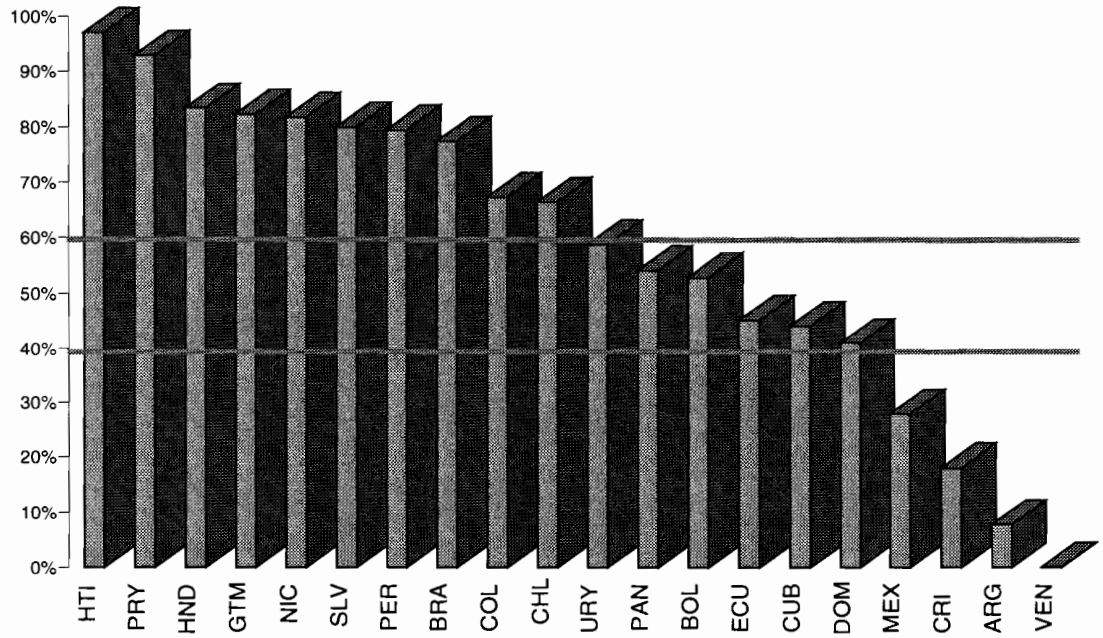
## 3. Residential Sustainability Index (RSI)

This indicator expresses the relationship between woodfuel consumption and the consumption of oil derivatives or secondary hydrocarbons (kerosene, diesel, liquid gas from oil) in the residential sector. It also indicates the importance of woodfuel to meeting energy caloric needs, mainly for cooking, heating and boiling water.

A high index reveals that the country is heavily dependent on woodfuel to meet its local needs and, as a result, it would be appropriate to further expand the analysis or have access to more details about the estimates used and the information base. This suggests that alternatives for proceeding with specific studies to recalculate the "renewable portion" of woodfuel should be pursued.

Aside from this aspect, a high RSI also has social implications, given that this indirectly reveals poverty levels among the rural and marginal-urban populations, and the lack of access to higher quality, more versatile and efficient energy sources.

Figure V.3
**LATIN AMERICA (20 COUNTRIES): RESIDENTIAL SUSTAINABILITY INDEX**
*(Woodfuel consumption/hydrocarbon consumption)*




**Source**: Own calculations based on SIEE figures from the Latin American Energy Organization (OLADE); the Food and Agriculture Organization (FAO), FAOSTAT.

Figure V.3 reveals that:

- Countries such as Argentina, Mexico and Venezuela, which are under the 20% line, are heavy users of secondary hydrocarbons, so should post a higher useful consumption than other countries.

- The countries within the range (more than 40% and less than 60%) can be considered "balanced" and at the limit for satisfactorily meeting their caloric needs.

- The Central American countries, Haiti, Chile, Brazil, Colombia, Paraguay and Peru post high RSI indices, pointing to an excessive dependency on woodfuel in both rural and marginal-urban areas. As a result, these areas apparently lack a suitable supply of the necessary basic calories, in terms of both access and quality.

### 4. Hydroenergy Dependency over Total Renewable Supply Index (HDI)

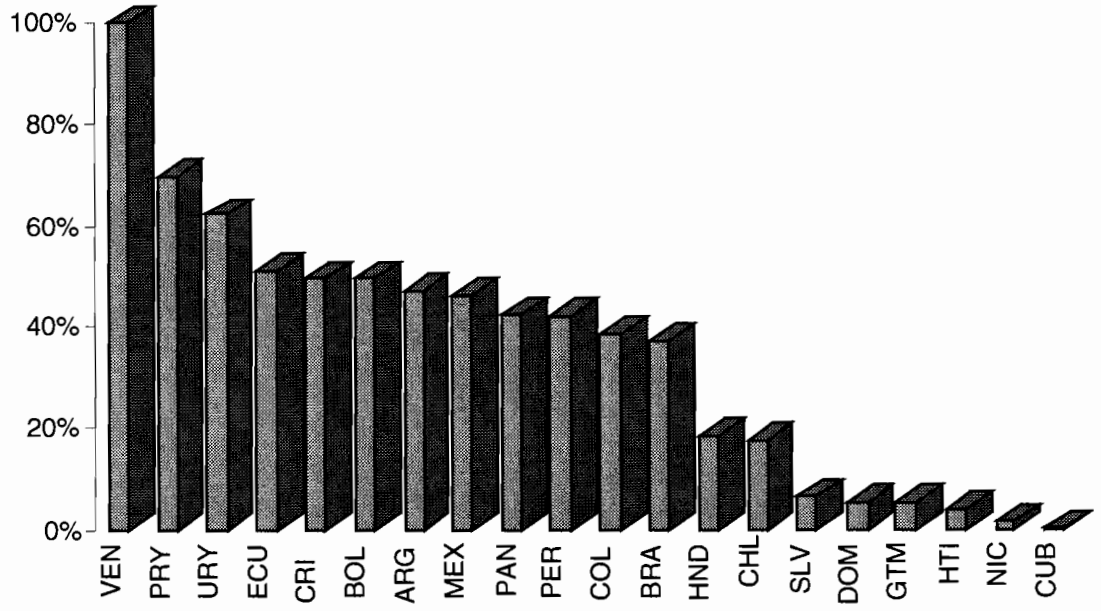
This expresses the relationship between the supply of hydroenergy and the supply of renewable energy, thus revealing the importance of hydroenergy within the "renewable" supply available within a country.

A high index signals that the country's share of renewable energy is more strongly linked to weather[13] rather than technological factors.

At one extreme are Venezuela, Paraguay and Uruguay posting high indices, because hydroenergy is their only source of renewable energy. On the other are Cuba, Haiti, and Nicaragua, because they have no significant hydroelectric resources, and therefore have very low indices. Finally, countries with intermediate levels (from 20% to 25%) are those that appear to be the most balanced in terms of the contribution from hydroenergy within renewables (figure V.4).

[13] Of course, according to these countries, this also depends on making the most of the installed capacity of the country's dams.

Figure V.4
**LATIN AMERICA (20 COUNTRIES): HYDROENERGY DEPENDENCY OVER TOTAL RENEWABLE ENERGY SUPPLY**
*(Total renewable hydro/total renewable energy, percentage)*

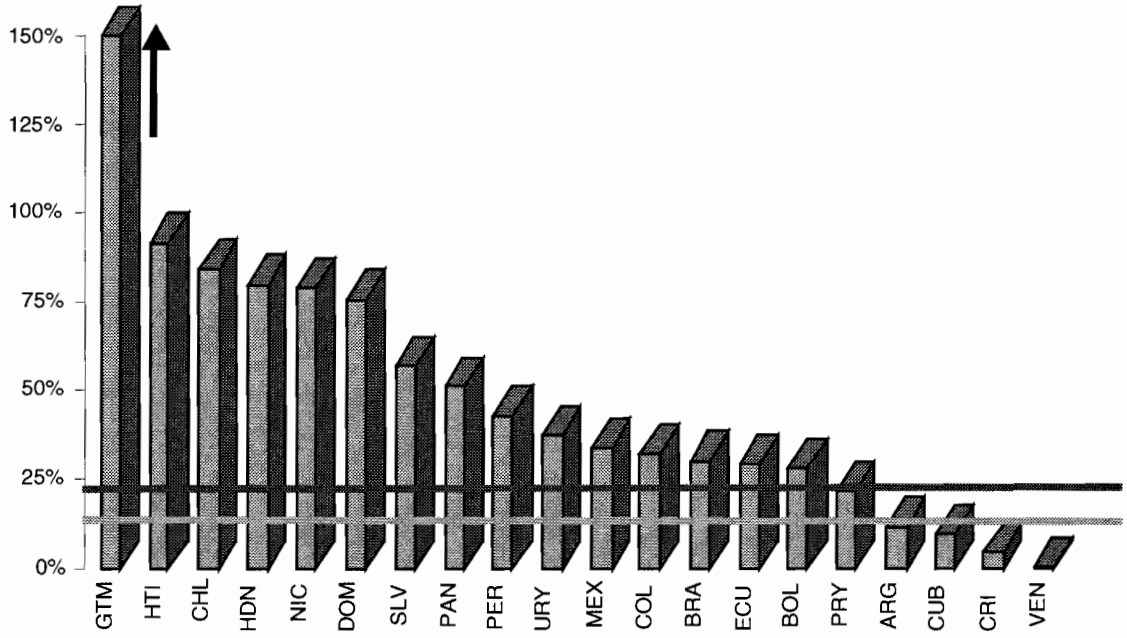



**Source:** Own calculations based on SIEE figures from the Latin American Energy Organization (OLADE); the Food and Agriculture Organization (FAO), FAOSTAT.

## 5. Forest Energy Dependency over the Total Renewable Supply (FDI)

This index expresses the total woodfuel supply over the total primary renewable energy supply. It indicates the importance of forest energy within a country's renewable supply. A high index signals that the country's share of renewable energy is tied to the intensive and therefore not always sustainable use of forest resources.

Figure V.5
**LATIN AMERICA (20 COUNTRIES): FOREST ENERGY DEPENDENCY OVER TOTAL RENEWABLE ENERGY**
*(Total renewable woodfuel/over total renewable energy, percentage)*




**Source**: Own calculations based on SIEE figures from the Latin American Energy Organization (OLADE); the Food and Agriculture Organization (FAO), FAOSTAT.

For a comprehensive and consistent analysis, the FDI should be compared (country by country) to the RSI. However, figure V.5 reveals that:

- The supply of renewable energy in the Central American countries (except Costa Rica) and in the Caribbean countries (except Cuba) is closely linked to the availability of woodfuel. In the case of Guatemala, the index is well over 200%, because as mentioned above, the Guatemalan Ministry of Energy and Mines has specified that 96% of woodfuel is produced unsustainably, so there is more non-sustainable than renewable consumption of this energy source.

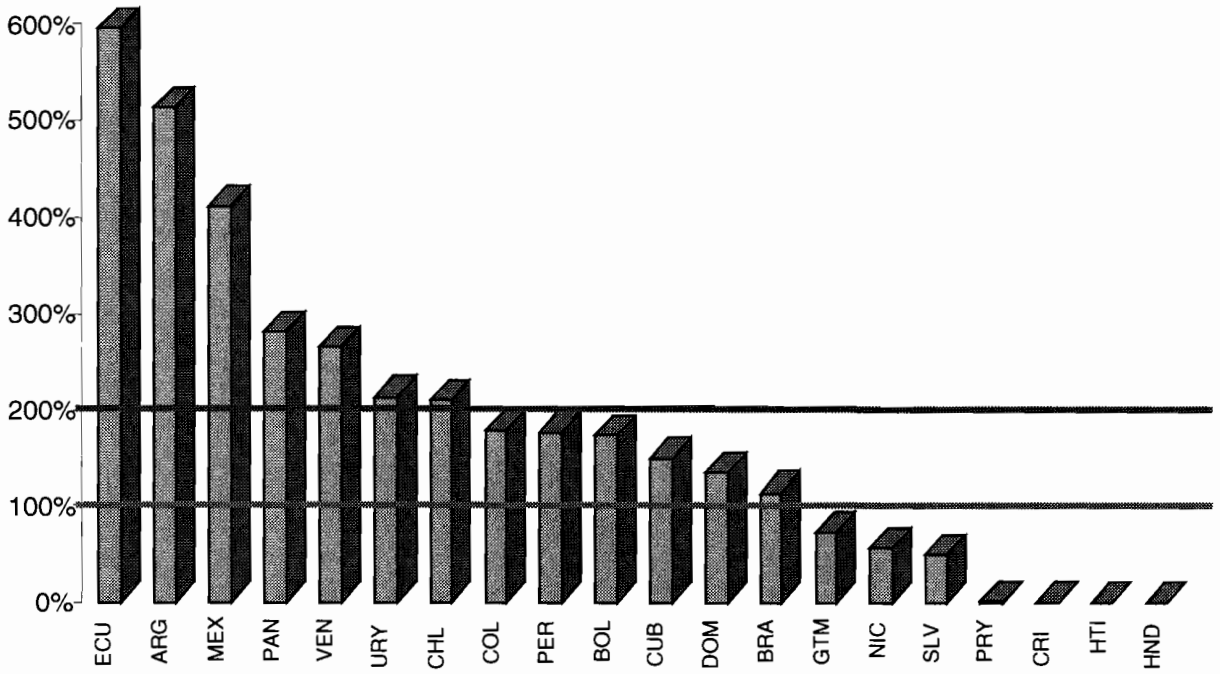
- Another country associated with this group of very forest-energy dependent countries is Chile, which (aside from hydroenergy) only uses woodfuel from renewable sources.

- Particularly outstanding among the countries that have managed to diversify their renewable supply and thus depend less on woodfuel are Costa Rica and Cuba. Likewise, Argentina, Paraguay and Venezuela also post low indices, reflecting the high percentage of hydroenergy within the renewable source group.

## 6. Oil Dominance Index (ODI)

Expressed as the relationship between the primary energy supply of oil and the total renewable energy supply in a country, this index reveals oil's importance within energy supply, in contrast to renewable energy availability and use.

Figure V.6
**LATIN AMERICA (20 COUNTRIES): OIL DOMINANCE INDEX**
*(Total oil energy supply/total renewable* energy supply)




**Source**: Own calculations based on SIEE figures from the Latin American Energy Organization (OLADE); the Food and Agriculture Organization (FAO), FAOSTAT.

In quantitative terms, a high index points to oil's predominance over renewables, in essence, polluting versus non-polluting sources. In some sense, this index can be considered to be inversely proportional to the sustainability of a given country's energy development.

A comparative analysis of the ODI for the region's countries in figure V.6 reveals that:

- As was predictable, the three main oil exporting countries, Ecuador, Mexico and Venezuela, along with Argentina, post indices over 200%. In the case of Venezuela, this index is somewhat lower, reflecting the important role played by the supply of hydroenergy. Chile also falls into this category despite being a net hydrocarbon importer, a situation that points to some vulnerability in its energy supply, which depends on sources abroad and could affect the country.

- Except for Panama, the Central American countries that are net hydrocarbon importers post very low values for this index, given that their respective energy supplies are mainly based on woodfuel. Costa Rica posts low values because, as mentioned above, it enjoys a diverse and balanced supply of renewables. Paraguay, which is also a net oil importing country, posts low values given the enormously substantial contribution from its hydro resources.

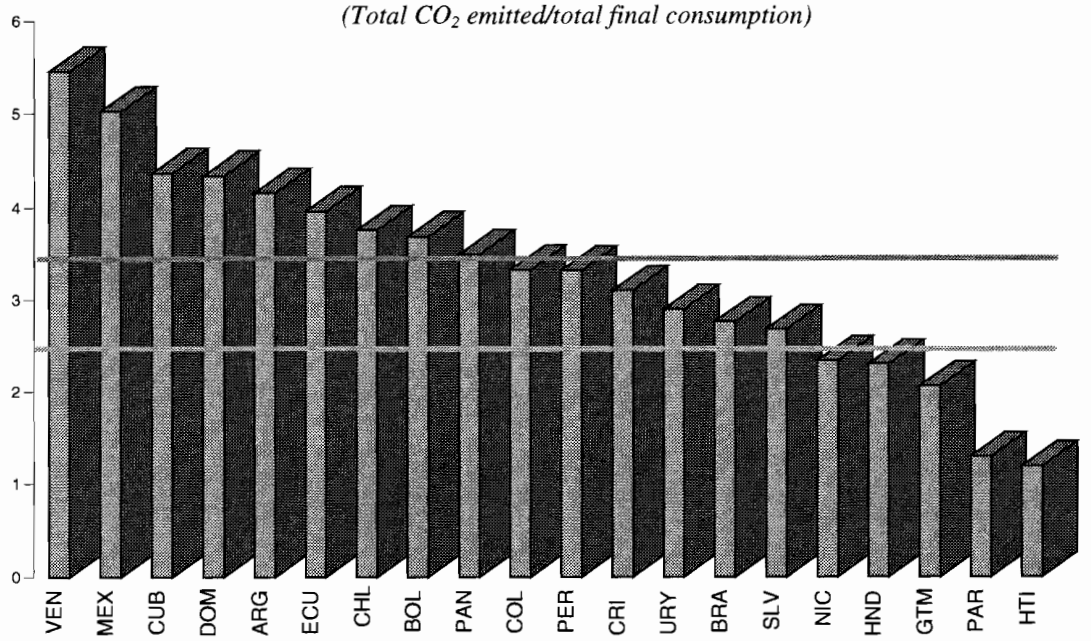
## 7. Polluting Consumption Index (PCI)

This expresses the relationship between total $CO_2$ emissions (in thousands of tons) emitted into the atmosphere and the country's total final consumption for that year (in thousands of oil-equivalent barrels); thus, a high index means that the country's energy consumption is particularly polluting.

For this index it would be important to compare it over time (for example, 1980-1990-2000), to identify specific trends.[14]

If a country already had a high index in 2000 and has continued to rise in the past 20 years, then this would clearly be a country with high overall environmental risk, since it is emitting an excessive and disproportionate amount of greenhouse gases per unit of consumption.

Figure V.7
**LATIN AMERICA (20 COUNTRIES): TOTAL POLLUTING CONSUMPTION INDEX**
*(Total $CO_2$ emitted/total final consumption)*




**Source**: Own calculations based on SIEE figures from the Latin American Energy Organization (OLADE); the Food and Agriculture Organization (FAO), FAOSTAT.

[14] An analysis of this nature would be beyond the extent of this study.

Figure V.7 reveals that:

- The Central American countries[15] post a low PCI reflecting their low dependency on oil within the TPES. Paraguay also posts a low index, due to the importance of hydroelectric power.

- The oil-exporting countries (Argentina, Bolivia, Ecuador, Mexico, Venezuela) and those whose TPES depends heavily on oil (Cuba, Chile, Dominican Republic) are the ones that comparatively speaking are emitting an excessive amount of greenhouse gas, thus contributing to global warming.

### 8. Electric Power Generating Pollution Index (EPI)

This indicator expresses the relationship between the amount of $CO_2$ emitted over total electric power generated. Although it represents a simplification, it does indicate how much the production of each GWh of electricity pollutes.

In quantitative terms, a high index signals that to produce that GWh of electricity —beyond the simple technical/operating cost of generation— there is a high environmental cost to the country, both locally (direct and indirect pollution around generating stations) and globally (substance emissions that contribute to increasing the greenhouse effect).

This index directly reflects the energy mix available to a country, and particularly the balance between the hydro-thermal generation capacity that is used. In countries that have no hydroelectric resources, clearly the EPI will be higher.

Figure V.8 reveals that:

- Costa Rica, Brazil, Paraguay and Uruguay[16] are relatively clean countries in terms of electric power generating processes. In Costa Rica's case this reflects, as mentioned above, the important "renewable mix" available to the country (geothermal, wind, hydroenergy,), while in the case of the latter three countries, the low index solely reflects their heavy dependency on hydroelectricity (compared to the HDI).

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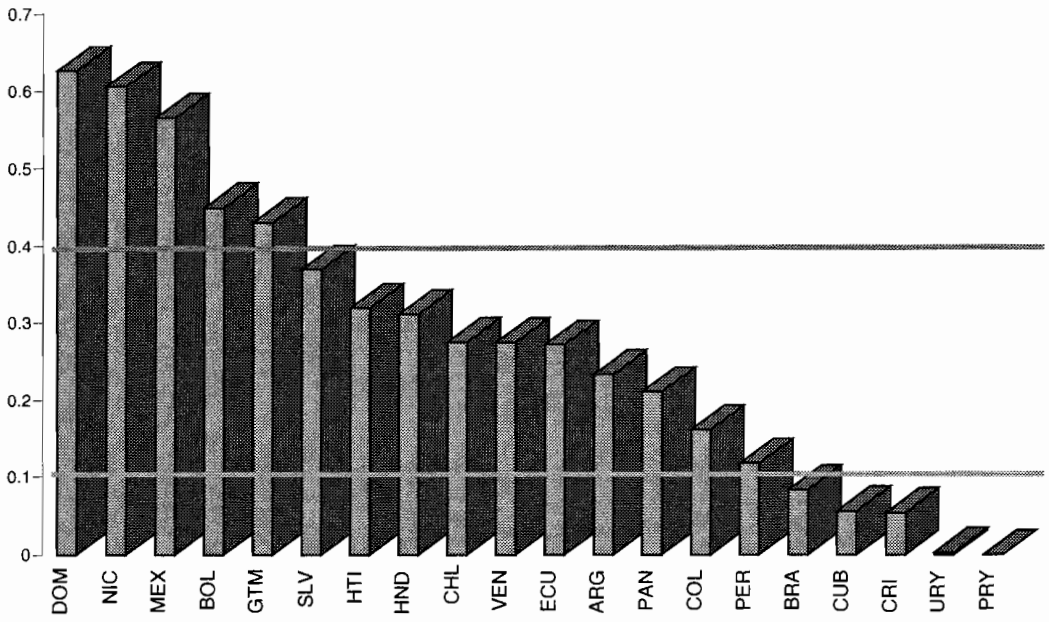
[15] Haiti, with extremely low polluting consumption indices seems to belong in this category, which raises some doubts since the country burns almost exclusively wood and oil derivatives for energy. Because of this, Haiti requires a more in-depth analysis, to confirm the origin and quantify the data used in this study.

[16] Cuba seems to fall into this category, with a particularly high indicator for oil dependency within its TPES, which raises some doubts since the technology currently used to measure sugar cane generation is not very efficient. Because of this, Cuba requires a more in-depth analysis, to confirm the origin and quantify the data used in this study.

Figure V.8
**LATIN AMERICA (20 COUNTRIES): ELECTRIC POWER GENERATING POLLUTION INDEX**
*(Tons of $CO_2$ produced by electric power generation/GWh of total electricity produced)*




**Source**: Own calculations based on SIEE figures from the Latin American Energy Organization (OLADE); the Food and Agriculture Organization (FAO), FAOSTAT.

- Mexico, Nicaragua, Bolivia, Guatemala and the Dominican Republic all show that their generation processes contribute significantly to pollution in terms of $CO_2$ emissions. In the case of Mexico and Bolivia, this reflects the dominant role of hydrocarbons within the TPES; in the other countries, this role is less significant (although still over 20%) and clearly associated with less efficient generation and low yields from thermal generating stations.

# VI. CONCLUSIONS AND PROPOSALS FOR FURTHER DEVELOPING THIS STUDY

Clearly the countries of Latin America present extremely different behaviours in terms of energy use, depending essentially on whether they are self-sufficient, export or import hydrocarbons.

Moreover, these results show that the contribution from renewable energy sources varies enormously from one country to the next, and is virtually independent of their comparative level of development and, to a lesser degree, their endowment of non-renewable energy resources. The reality of the Total Primary Energy Supply and energy issues in countries such as Argentina, a self-sufficient country that exports some hydrocarbons, is very similar to that of major exporters such as Mexico and Venezuela. These conditions are completely different, however, to those in importing countries. Even in the case of the latter, however, the difference between Haiti, Honduras and Guatemala and Uruguay and Costa Rica, for example, is surprising.

An analysis of the information presented in this study reveals the predominant role of forest energy in the Total Primary Energy Supply of countries such as Guatemala, El Salvador, Honduras, Nicaragua and Haiti. This fact can be considered positive in terms of sustainable development, due to the reduced use of fossil fuels, but at the same time is a source of concern and to some extent negative, given the powerful impact and pressures on national forest resources and the consequent rise in $CO_2$ due to burning woodfuel.

But even in the countries where biomass use to produce energy is very slight, problems with sustainability may also exist due to the heavy use of fossil fuels at every level: in final consumption and industrial, residential or intermediate consumption, such as electrical generation. This group of countries includes Argentina, Mexico, Venezuela, and Ecuador.

Finally, one category of countries has mixed problems. This is the case of Cuba where cane derivatives could be used in inefficient combustion processes; the Dominican Republic and Panama, which show a low efficiency in their thermal transformation of imported fossil fuels; and Chile and Uruguay, which depend almost exclusively on imported oil and hydroenergy.

Several countries fall outside the standard levels, with over 90% of renewable non-forest energy and less than 2% oil in the TPES: this is the case of Paraguay, essentially a country with hydroelectric power, and Costa Rica, the country with a good balance of renewables, given the very diversified composition of its TPES, which includes shares held by geothermal, hydro, cane products, forest energy and wind power.

Based on this general differentiation, the regional study carried out for each countries' TPES in 2000, and taking into account the direct and comparative performance indices, it would be a good idea to expand and conduct a more in-depth analysis of:

(i) the renewability fractions of the different applications of primary woodfuel (based on the methodology proposed by Brazil) in selected countries. This should focus on

those countries that although they post a large share of renewable energy within their TPES, remain heavily depending on woodfuel for their energy supply, as occurs in the case of the Central American countries (except Costa Rica), which therefore may post high shares for non-sustainable forest energy;

(ii) the problems and obstacles apparent in implementing policies to promote and encourage renewable energy use in selected countries. This should focus on countries with a very low share of energy from renewable sources in their TPES, as is the case with Argentina, Ecuador, Chile and Mexico, that is those countries that could face serious difficulties meeting the 10% renewable target proposed by the Latin American Initiative;

(iii) the real room for improvement available to countries such as Brazil and Cuba, dependent on oil for more than 50% of their TPES but with enormous potential for alternative renewable resources other than hydroenergy, particularly cane products and wind energy;

(iv) the problems and obstacles to the efficient use of renewable resources, in particular cane products and "other biomass", in countries such as Peru, the Dominican Republic and Haiti.

(v) the environment, in terms of regulations and economic measures necessary for the penetration of modern wind, solar, geothermal, SUR[17] combustion in countries with these resources currently sitting idle at the same time as they are heavily dependent on imported oil, as is the case with Chile, Panama, Colombia and Ecuador.

As expressed above, the specific purpose of this study was to analyse the sustainability of primary energy in 2000. This involved portraying the situation in 2000, which led to positive conclusions in some cases and raised further questions in others.

Dealing with the issues analysed here in a dynamic rather than a static fashion remains pending. This involves proposing a series of possible scenarios for countries in Latin America and the Caribbean and examining the national, subregional and regional limitations, to help those countries or subregions that have been unable to meet the Latin American Initiative target to approach those goals. And in the case of those that are compliant, finding ways to redirect trends and policies toward the energy sector's sustainable development.

[17] SUR, Solid Urban Residues.

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