Proyect Document

Renewable energy sources in Latin America and the Caribbean: two years after the Bonn Conference

Coordinated by Manlio F. Coviello

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Economic Commission for Latin America and the Caribbean (ECLAC)

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Summary

In recent years there have been a number of events and advances in the region's renewable energy sector in both regulatory and project terms

Significant advances have been made in the regulatory field, including: Argentina's Provincial Plan for the Promotion of Renewable Energies, approved with force of law by the Legislature of the Province of Santa Cruz in 2005; Law No. 26093 instituting the Plan to regulate and promote the Production and Sustainable Use of Biofuels in the Republic of Argentina; Regulation No. 004/04 of 2005, in which Ecuador's National Electricity Council (CONELEC) approved the rules and prices governing the operation of renewable energy generating plants; the approval by Mexico's Chamber of Deputies of the Law on the Use of Renewable Energy Sources (LAFRE), which provides for the creation of a trust to ensure that renewables account for 12% of total domestic energy generation by 2012; and Nicaragua's Law for the Promotion of Electric Power Generation using Renewable Sources of 2005.

There have also been major advances in the project field, including the tangible progress made by Brazil with Law No. 10438/02 of 2002 establishing the Incentive Programme for Alternative Energy Sources (PROINFA). The programme's first project was put into operation in February 2006 (Coruripe biomass combustion plant). It is the Brazilian Government's intention to increase the country's installed capacity in alternative energies to 1,000 megawatts (MW) by late 2006, with the entry into operation of 37 new plants, and for all the plants in the programme to be operational by late 2007. In Chile, the Production Development Corporation (CORFO) and National Energy Commission (CNE) launched the second call for non-conventional renewable energy projects in June 2006, which is designed to partially finance pre-investment studies or specialist consulting.

In 2005, the Federal Electricity Commission started building Mexico's first large-scale wind power plant in the State of Oaxaca, which will come into operation in October 2006. In addition, Mexico's Secretariat of Energy (SENER) plans to build a further 500 MW of wind power capacity in the coming years, with the aim of achieving 588 MW of installed capacity by the year 2014. In March 2006, the World Bank's Board of Executive Directors approved a US$ 50 million loan for Peru, in addition to a donation of US$ 10 million from the Global Environment Facility (GEF) to improve access to efficient and sustainable electricity services in rural areas. Also worthy of mention is the inauguration, in May 2006, of a new geothermal plant

at the Berlin power plant belonging to state geothermal company LaGeo in El Salvador, designed to add a further 40MW of capacity.

The Energy and Environment Partnership with Central America (EEP) has been particularly active in terms of projects, having spent more than 3 million euros to date in implementing 77 projects in the seven countries of the Central American subregion.

The trend in total renewable sources as a share of total energy supply is slightly down, falling from 25.7% in 2002 to 24.8% in 2004

A comparison of the composition of total energy supply (TES) for 26 Latin American and Caribbean countries between 2002 and 2004 shows marginal changes between the share of fossil and renewable natural resources, with natural resources representing approximately one quarter of the region's total energy supply.

As regards hydrocarbons, there has been an increase in the supply of oil and a significant decrease in natural gas throughout the region. This might lead to the conclusion that the region is not set on a "virtuous energy path", as would have been the case if there had been an increase in environmentally cleaner hydrocarbon energy like natural gas. However, this initial conclusion needs to be treated with caution. A glance at the countries' TES data shows that the regional analysis is heavily influenced by a large increase in oil supplies in the Bolivarian Republic of Venezuela (a 54% rise compared with 2002) and by a steep reduction in the supply of natural gas in the same country (a 23% drop compared with 2002). In all the other countries and subregions (excluding the Andean Community of course) the trend is reversed, although the heavy impact of a hydrocarbon-rich country like the Bolivarian Republic of Venezuela distorts the overall interpretation of trends.

The share of coal in TES increased markedly owing to a significant increase in supply in Mexico, Costa Rica and the Dominican Republic. In addition, the share of nuclear energy exceeded 1% for the first time, owing to substantive input from the Angra II power plant in Brazil.

The progress that many countries of the region have made with renewable energies has still not markedly increased their share of renewables

The trend in the share of renewable sources as a whole was down slightly, with a 3.5% drop from 25.7% in 2002 to 24.8% in 2004. This indicates that the significant advances which many countries in the region have made in the renewable energy sector in recent years (in terms of both regulations and project implementation), have still not been reflected in an increased share for renewable sources in the energy structure.

The downturn in renewable energies stems chiefly from a sharp decrease in hydroelectricity supply, particularly in Brazil, Uruguay, Colombia and Mexico. There was also a drop in the supply of both geothermal energy (the growth of which has stagnated over the past five years, particularly in Mexico) and sustainable residential fuelwood. The supply of cane products has increased (primarily owing to steady growth in bioethanol production in Brazil), as has that of other renewable energies, the share of which has risen sharply mainly as a result of new wind power projects in countries like Brazil, Jamaica and Costa Rica.

Brazil was the only country to have substantial growth in the share of renewables between 2002 and 2004

This rather discouraging picture of renewable energy supply was confirmed by an analysis of subregional energy performance indices in 2004. An analysis of the energy supply renewability index (the ratio between the total supply of all renewable energies and total energy supply), showed that the only country to have shown substantial growth in the share of renewables between 2002 and 2004 was Brazil, which is starting to see the benefits of its efforts in terms of policies to promote alternative energies (the PROINFA, Prodeem and 'Luz para Todos' programmes).

By contrast, the Eastern Caribbean subregion still comes considerably below the 10% threshold (the government commitment in the Brasilia Platform). Mexico, where the share of renewables was slightly above the 10% threshold in 2002, dropped below the threshold in 2004. This means that the Eastern Caribbean countries and Mexico will need to work hard to meet the target of renewables as a share of total energy supply.

The subregions which came within the 20% to 30% range in 2002 (Greater Antilles and the Andean Community) have not substantially increased their renewable share, so they need to take decisive action, both in policy terms and by promoting renewable energy projects, if they wish to maintain their current share of renewables in TES at above the 10% threshold.

Bioethanol is already a reality in a number of Latin American and Caribbean countries

As the various national initiatives and programmes demonstrate, bioethanol is already a reality in a number of Latin American countries (although objectives, production structures and scales differ). All projects tend to use sugarcane or molasses as feedstock and there are prospects for growth in all the countries studied. Clearly then there is potential for expanding the use of bioethanol in the region.

A preliminary exercise conducted as part of this study to explore the impact of a 10% bioethanol mix in gasoline has shown that an average 35% of the region's biofuel requirement could be met either by using existing molasses or by increasing the current sugarcane-growing area by 22%, which is around 0.4% of the utilized agricultural area. Cuba, Guatemala, Guyana and Nicaragua present particularly high potential for producing bioethanol from molasses, in excess of the requirements for a 10% bioethanol mix in gasoline. At the other extreme, the sugarcane processing industry in Haiti, Surinam, Uruguay and the Bolivarian Republic of Venezuela is too small to produce even 10% of bioethanol requirements for a 10% mix in gasoline. From the land availability standpoint, the possibilities would seem to be endless as, with the exception of Barbados, Jamaica, Trinidad and Tobago, Surinam and the Bolivarian Republic of Venezuela, enough bioethanol could be produced for the 10% mixture by using less than 1% of the countries' agricultural area.

It is important to promote information programmes to publicize the advantages and drawbacks associated with the production and efficient use of bioethanol

In general there do not appear to be any major barriers to the development of bioethanol in the region, apart from the scant information available on the advantages, drawbacks and sustainability of bioethanol production and use. It is therefore important to promote information programmes to publicize the advantages and drawbacks associated with the production and efficient use of bioethanol, whilst acknowledging the diverse views, objectives and scope of social and economic operators, so as to achieve the required consensus for a gradual transition from fossil to renewable energy resources. In any case, for it to be effective and sustainable, any decision to adopt bioethanol must be the result of careful consultation between the aforesaid interests, with the welfare of society as a whole as a primary goal.

It is important to analyse how far the Brazilian bioethanol experience can be replicated in other countries of the region

It must emphasized that, with the exception of Brazil, large-scale biofuel production has only proven to be feasible, with certain guarantees, in eminently industrialized countries. Brazil's bioethanol industry is mature, with a highly favourable cost structure, and could be expanded significantly in the future in response to growing demand. The most important aim is to ascertain how far the Brazilian bioethanol experience can be replicated. To do this, a number of key questions need to be answered: (i) Could the bioethanol industry (and the biofuel industry in general) be financially viable without government support? (ii) Is such support justifiable in certain cases? (iii) Which factors affect the financial and economic viability of programmes for producing (or expanding the production of) bioethanol?

Progress in initiatives for the gradual incorporation of biodiesel programmes in some Latin American countries is still very recent

A preliminary exercise to explore the potential of countries in the region to produce biodiesel, also conducted as part of this study, which makes a country by country comparison of the scale of exports of oil-bearing feedstocks and the total number of diesel-powered vehicles, showed that some of the countries with the best potential availability of biodiesel are Argentina, Bolivia, Brazil, Costa Rica, Honduras and Paraguay, which are the very same countries that export fairly large quantities of vegetable oil.

Whereas the production and use of bioethanol fuel in the region date back almost a century, progress with initiatives for the gradual adoption of biodiesel has been made only recently in a few Latin American countries. Biodiesel, an organic fuel, can be turned into an effective substitute for crude-oil-derived diesel, provided that its real feasibility can be irrefutably demonstrated, especially in terms of energy balance and productivity. Europe's experience with biodiesel comes from agricultural policies that are hard to replicate in the region, with high subsidy levels and more or less apparent protectionist systems.

A possible means for increasing the penetration of biodiesel is to identify uses with greater added value

An analysis of the trend in the international prices of vegetable oils and diesel in recent years shows clearly that, in terms of financial viability, the prices of vegetable oils have been systematically higher than the price of diesel. Therefore, when proposing the use of a vegetable oil as fuel, apart from ensuring that it costs less than the selling price (whether or not compensation, tax waiver or subsidy mechanisms are used), it is essential to ascertain whether an alternative use exists that would yield higher profits, that is to say, whether there is an opportunity to add more value to the product. One way to define opportunities for increasing the feasibility of biodiesel is therefore to identify uses with greater added value. Biodiesel is usually proposed because of its potential environmental benefits in reducing emissions, with other aims being to substitute imported diesel or to boost the agro-industrial sector.

It is recommended to develop and further define analyses that introduce diverse variables and alternatives for evaluating the financial, economic and social viability of biofuel production

It appears to make sense for the public sector to play a role in the biofuel sector for a number of reasons: to eliminate regulatory barriers to investment in biofuels; to raise public awareness about the proper use of biofuels (and about reducing rising consumption levels) and to analyse the external costs that biofuel production could impose on society as a whole. It is advisable, therefore, to develop economic analyses that introduce diverse variables and alternatives for evaluating the financial, economic and social viability of biofuel production.

The sustainable development of biofuels (both bioethanol and biodiesel) in Latin America and the Caribbean will therefore call for a major concerted multisector analytical effort by the Governments of the region. This should aim to lay sound foundations for the design of national plans to promote biofuels. Any national plan for the sustainable development of biofuels must rise to the multidimensional challenge of: (i) defining technically robust and sufficiently tested alternatives; (ii) making a cautious analysis and prioritizing objectives; (iii) preparing the process for introducing the new fuel; (iv) establishing technical specifications for pure and blended fuels; (v) assessing optimum logistical and storage conditions; (vi) establishing a clear legal framework that is consistent with the fuel market; (vii) exploring the usefulness of adopting mechanisms to capture externalities.

Latin America leads the carbon market with 49% of registered projects and is the foremost supplier of CDM projects

The carbon credit market proved to be particularly active, with a total of 259 projects approved and registered by the Executive Board of the Clean Development Mechanism (CDM) by August 2006 to generate carbon credits under the Kyoto Protocol. On that date, Latin America was leading the carbon market with 49% of registered projects, followed by India with 31% of projects, China with 6% and the rest of the world with 14%. Latin America has been the foremost supplier of CDM projects since the earliest days of the Kyoto flexibility mechanisms. If a country's importance in the CDM market were to be based on the number of registered projects, India is the most important country, followed by Brazil, Mexico and China. Brazil and Mexico together represent 61% of registered projects in Latin America, which confirms that the large economies offer greater opportunities for supplying CDM projects.

In general, the region's CDM project portfolio is dominated by renewable energies which, while they do not contain as many emission reductions per project, have a much greater impact on sustainable development than do China and India's large-scale HFC-23 (trifluromethane) and N_2O (nitrous oxide) decomposition projects for reducing greenhouse gases with high global warming potential.

The most important sector in the region in terms of emission reductions is the destruction of methane from sanitary landfills

Taking into consideration all the projects submitted to the United Nations which have been registered and are in the application phase, the most important sector in Latin America and the Caribbean (in terms of emission reductions) is the destruction of methane from sanitary landfills, which represents 31% of all reductions. A glance at the projects currently applying for registration shows that the region's potential lies in biomass projects (such as bagasse cogeneration or energy based on other types of biomass like rice husks), managing solid animal waste (such as animal confinement farms in the agricultural sector), hydroelectric projects and solid municipal waste projects.

In general, CDM projects in the region face not only barriers common to all renewable energy projects, but also barriers arising specifically from CDM regulations, the main requirements of which are: (i) additionality; (ii) use of an approved methodology; (iii) a Host Country Letter of Approval for CDM projects; and (iv) there must be no official development aid. According to the additionality requirement, CDM projects must show, first, that they do not form part of the baseline (the most probable future scenario) and, second, that projects could be implemented only with the economic incentive of the CDM.

Even though the future of the CDM in Latin America relies on renewable energy projects, initiatives to support their development could jeopardize their "eligibility" as CDM projects

This means that it is highly unlikely for very profitable projects or ones that do not encounter greater barriers because they are part of common practice, or other projects included in government policies, to be approved by the CDM. Paradoxically, even though the future of the CDM in Latin America relies on renewable energy projects, initiatives to support their development could jeopardize their eligibility as CDM projects. In some cases, the CDM rules have created the perverse incentive of postponing government support for renewables in certain sectors in order to make CDM projects eligible.

A number of economic models based on mitigation costs predict a demand for certified emission reductions (CER) of 200 million tons per year. To date, projects amounting to more than 152 million tons of carbon dioxide equivalent (tCO2e) reduced per year have been identified as being in the application phase or registered by the CDM Executive Board. Bearing in mind that many of the projects applying for registration will not be registered and that some registered projects will not be implemented, there are still opportunities for a large number of CDM projects which, at the very least, will need to represent annual reductions of more than 50 million tCO_2e in order to meet the predicted demand for CER.

This is particularly encouraging for the region, since the future portfolio of CDM projects will comprise a much larger number of projects as there will be fewer large-scale emission reduction projects (HFC-23 and N_2O). This should give greater impetus to renewable energies in this market, particularly in Latin America and the Caribbean.

Chapter I
Advances in renewable energies in Latin America and the Caribbean

I.1 Background

(A) *Brasilia Platform on Renewable Energies*

The regional follow-up meeting to the World Summit on Sustainable Development,[1] held by the Government of Brazil in Brasilia on 29 and 30 October 2003, was attended by representatives of Ministries of the Environment and Energy of Latin America and the Caribbean.

The purpose of the Brasilia event was to create an opportunity to bring together initiatives and focus discussion on the problems and opportunities specific to the countries of the region, in order to define a common regional position in advance of the Bonn International Conference for Renewable Energies.

As the event ended, government representatives from 21 of the region's countries approved the Brasilia Platform on Renewable Energies, whose main commitments are summarized in box 1.

The Brasilia event made it possible to jointly and synergically discuss the opportunities and benefits available to the region under the different world scenarios for promoting renewables, regardless of whether Kyoto is ratified.

Although this document makes no specific political or institutional commitments, the Platform has nonetheless been an important step for the region's countries, since it represents the first concrete effort to coordinate and harmonize the countries' different focuses and interests in terms of sustainable renewable energy.

In fact, Brasilia represented an important opportunity to concentrate and consolidate the regional discussion agenda on renewable sources and to guide it towards initiatives that include designing a joint regional proposal, so as to position Latin America strategically vis-à-vis the different future scenarios for the development of renewable sources and the world carbon market.

[1] Pursuant to the Latin American and Caribbean Initiative for Sustainable Development (ILACDS).

A specific requirement of the Platform was that ECLAC should be the regional institution responsible for the follow-up and implementation of its agreements, which included convening a regional conference to follow up on the International Conference for Renewable Energies held in Bonn, Germany.

BOX 1
MAIN COMMITMENTS OF THE BRASILIA PLATFORM ON RENEWABLE ENERGIES

To further efforts to achieve the goal set forth in the Latin American and Caribbean Initiative for Sustainable Development of ensuring that by the year 2010 the use of renewable energy by the region, taken as a whole, amounts to at least 10% of its total energy consumption on the basis of voluntary efforts and taking into account the diversity of national situations. This percentage may be increased by those countries or subregions that voluntarily wish to do so.

- To strengthen cooperation between the countries of the region and the developed countries in promoting economic growth, environmental protection and social equity...
- To foster the formulation of the long-term public policies needed to further the development of renewable energy sources, in accordance with the regulatory frameworks in place in each country...
- To promote, at the level of each country, cooperation with the production sector in order to form alliances and gain more in-depth knowledge of the renewable energy sector.
- To foster the adoption of regulatory and institutional frameworks that incorporate instruments which internalize the social and environmental benefits of renewable energy.
- To facilitate the training of human resources for, inter alia, the diffusion of technology...
- To undertake, with the support of the Economic Commission for Latin America and the Caribbean (ECLAC) and other international agencies, an exchange of experiences regarding applicable regulatory frameworks for the development of renewable energy sources with a view to the following objectives:
  (a) Development of a comparative table on regulatory frameworks in the region.
  (b) Formulation of proposals for strengthening the sustainability of existing regulatory frameworks, in accordance with the situation in each country, and for promoting greater energy efficiency.
- To express strong support at the International Conference for Renewable Energies (Bonn, 2004), for the creation of a technical and financial cooperation fund to permit the reduction of existing costs and to increase investment...
- To urge financial institutions to finance national, subregional and regional renewable energy projects...
- To encourage the development of renewable energy projects and the creation of markets for green tags and carbon emission credits and the execution of tax incentive programmes...
- To formulate public policies that encourage the development of renewable energy markets.
- To take into account the social needs in the countries of the region when developing renewable energy markets...
- To request the Executive Secretary of the Economic Commission for Latin America and the Caribbean to prepare a document on the status of renewable energy in Latin America and the Caribbean for presentation at the International Conference for Renewable Energies and to provide support to the countries of the region at the International Conference and in the follow-up and implementation of the agreements reached at that event, including the convening of a regional follow-up conference within the framework of the United Nations.
- To declare that this platform for action constitutes a Latin American and Caribbean contribution to the International Conference for Renewable Energies and to instruct the Chairperson to present it at that Conference.

Source: ECLAC document, Series LC/L 2132 (2004)

(B) International Conference for Renewable Energies (Bonn 2004)

From 1 to 4 June 2004, the German city of Bonn hosted the International Conference for Renewable Energies. German Federal Chancellor, Gerhard Schröder, had announced the conference at the World Summit on Sustainable Development in Johannesburg in September 2002, in response to the Johannesburg Summit's call to promote the global development of renewable energies.

One of the key objectives of the conference was to identify the best strategy for promoting and using renewable energy sources, resolutely building on the proposal of the Johannesburg Renewable Energy Coalition (JREC).

More than 1,000 experts attended the conference, among them representatives from government delegations headed by ministers of energy, the environment and development, as well as representatives of the United Nations System of organizations and other international and non-governmental organizations, civil society and the private sector.

The German Government's three objectives prior to the conference were all amply achieved with the following outcomes:

- Agreement on a policy declaration recognizing the urgent need to adopt measures to speed up the use of renewable sources in energy generation, as well as to intensify energy efficiency schemes and programmes.
- The adoption of an international action plan that so far includes 165 projects from various countries, regions, organizations and firms aimed at adopting voluntary and quantifiable commitments on renewable energies.
- Recommendations on good practice in the form of measures and actions to promote the development of renewable energy markets.

As specifically commissioned by the Brasilia Platform, ECLAC prepared and officially presented to the Bonn Summit the document "Renewable Energy Sources in Latin America and the Caribbean: Situation and Policy Proposal."[2] This document confirmed that, by late 2002, Latin America and the Caribbean had met the targets laid down in Brasilia, with renewable energies contributing more than 25.7% of total energy supply. These renewable energies included hydroenergy, with approximately 15% of total energy supply, fuelwood with 5.8% and cane products with 4.1%. The remaining renewable sources made a marginal contribution: biomass with 0.5% and geothermal energy with 0.7%. Even though wind and solar energy sources are used, they are not yet counted as part of the energy supply.

The document revealed that the target achieved by the region as a whole must be treated with caution, as marked differences were observed not only among the subregions but also among countries in the same subregion, in areas such as: (i) natural resource endowment; (ii) energy supply and consumption structures and (iii) institutions with the capacity to conduct policies for renewable energy promotion and penetration.

I.2 Recent advances in the renewable energy sector

On 3 August 2006, the President of **Argentina** presided over the official ceremony to present the National Wind Power Plan at Government House, designed to promote Argentina's energy capacity, as well as to boost its economic growth through job creation.

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2 Document of the Economic Commission for Latin America and the Caribbean (ECLAC), Series LC/L 2132 (see ECLAC website: www.eclac.org/id.asp?id=14981).

The progress achieved in terms of energy in the Province of Chubut made it possible to carry out studies to produce a wind energy potential map of Argentina (*Mapa Eólico de la República de Argentina*), with two development programmes: the wind energy plan for Patagonia I, in Chubut Province, and the wind energy plan for Patagonia II, in Santa Cruz Province.

Santa Cruz is the only province to be implementing a Provincial Plan for the Promotion of Renewable Energies, approved with force of law by the Legislature of the Province of Santa Cruz (Law 2796 of August 2005). The law promotes electrical and/or thermal power generation from renewable wind, solar and tidal resources, hydropower up to 15 MW, biomass or other energy sources classified as non-polluting. The law provides for a ten-year exemption from all provincial tax levies on activities to manufacture equipment and systems for exploiting renewable energies.

A subsidy of between 0.01 and 0.03 Argentine pesos has been established for each kilowatt/hour of renewable energy generated, depending on the percentage of national or provincial equipment and/or generating systems involved.

The Provincial Energy Development Fund was created for the purpose. The fund will comprise: (a) money from fines or judicial or extrajudicial claims for improper settlement of hydrocarbon royalties; (b) fees for exploring and operating hydrocarbon areas; (c) royalties received in excess of the value set in Argentina's National Hydrocarbons Law; (d) dividends from the province's holding in the national enterprise Energía Argentina, S.A. (ENARSA); (e) public and private contributions; (f) funds from the Provincial Budget.

Lastly, Argentina's Energy Ministry, in coordination with the Federal Electricity Council (CFEE), is once again promoting a bill - drafted by Senator Pedro Salvatori de Neuquén - on a system to boost the use of renewable sources for electricity generation. This bill, which failed to be approved in two successive parliamentary periods, now enjoys a climate more conducive to discussion, creating a new political will for re-tabling the bill. The bill sets a target of achieving an 8% share of renewables in domestic electricity consumption and stipulates a maximum capacity of 30 MW for hydroelectric power plant projects.

Under this initiative, by virtue of Law No. 24065 on electricity generation, distribution and transportation, Argentina's Energy Ministry will increase the levy within the margins set by itself up to 30 Argentine cents per megawatt/hour (MWh), which shall be used to establish the renewable energy fund (FER) to be administered and allocated by the Federal Electricity Council. Its objective will be to pay 1.5 Argentine cents per kilowatt-hour (KWh) generated by wind power systems; up to 90 Argentine cents/KWh generated by solar systems; 1.5 Argentine cents/KWh generated by geothermal, tidal, biomass, landfill gas, sewage gas and biogas systems and up to 1.5 Argentine cents/KWh generated by new hydroelectric systems of up to 30 MW installed capacity.

As regards bioenergy, Law No. 26093 was promulgated in Argentina on 12 May 2006, instituting the plan to regulate and promote the production and sustainable use of biofuels. Law No. 26093 created the institutional framework for biofuels in Argentina and stipulates that, as from 2010, all fuels classified as diesel oil or gasoline marketed on Argentine territory should be mixed with 5% biodiesel or bioethanol respectively, thereby laying the foundations for launching their commercial production and promotion.

In addition, the law establishes a system of promotional benefits that prioritizes projects involving small and medium-sized enterprises, agricultural producers and regional economies. The decision to introduce biofuels into Argentina's energy structure is vital because of its environmental implications (reduction in carbon emissions); economic implications (depletion of fossil fuels in the face of continuously growing demand and the agricultural sector's potential to position itself as an energy source, generating investment, jobs and added value for the marketing chain); social implications (creation of opportunities for small and medium-sized agricultural holdings and for regional economies) and strategic implications (promotion of "transition energies" to boost the use of renewable sources).

In **Brazil,** Law No. 10438/02 of 2002 established the Incentive Programme for Alternative Energy Sources (PROINFA), which provides incentives for biomass- and wind-powered thermoelectric power plants and for small hydroelectric power plants to get connected to the national grid. In addition to stipulating a compulsory total purchase of 3,300 MW generated using renewable energies up to late 2006, PROINFA is seeking to achieve a 10% share of renewable sources in total electricity production in the next 20 years.

In the electricity purchase contracts with a 15-year guarantee concluded with the federal electricity enterprise ELETROBRAS, the price is based on the weighted average cost of generation using thermoelectric power plants driven by natural gas and hydroelectric plants with a capacity of more than 30 MW. The price paid for the energy will be distributed equally among consumers of energy from wind, biomass and small hydroelectric power plants. The prices of PROINFA projects were set by the Ministry of Mines and Energy and ELETROBRAS, based on technical aspects and on market conditions for each of the energy sources. An economic value of 104 Brazilian reals was defined for biomass plants, 134 reals for mini-electric power plants and between 220 and 230 reals for wind power plants.

The original programme was for ELETROBRAS to buy some 12.6 million MWh per year as from 2006, which would guarantee a turnover of around 1.8 billion reals to investors and the creation of some 150,000 direct jobs for Brazil as a whole.

Despite the efforts of the Ministry of Mines and Energy to comply with the deadline set by PROINFA for early 2006, the plants in the programme were delayed owing to problems with project finance. A point of note is that most producers could be classified as "independent producers", which makes them vulnerable to guarantee problems during the technical/administrative approval process (audit list of the Brazilian Electricity Regulatory Agency (ANEEL)), as well as during the environmental approval process.

The introduction of a special line of credit for PROINFA projects by Brazil's Economic and Social Development Bank (BNDES) enabled the programme's first project to be put into operation in February 2006: the Coruripe biomass factory in the State of Alagoas, which cost US$ 16 million for 16 MW of installed capacity.

Up to now, ELETROBRAS has signed power sales contracts with 144 PROINFA projects. Of these projects, only five have started commercial operation, producing a total of 134 MW:

- Coruripe biomass plant, Alagoas 16 MW
- Osorio I windmill park, Rio Grande do Sul 50 MW
- Rio do Fogo windmill park, Rio Grande do Norte 50 MW
- Carlos Gonzatto mini-hydroelectric station, Rio Grande do Sul 9 MW
- Agua Doce wind power plant, Santa Catarina 9 MW

However, the Brazilian Government predicts that alternative energy generation in Brazil will increase by 914 MW by late 2006 when 37 new plants come into operation (17 biomass combustion, 10 wind power and 10 mini-hydroelectric plants). All the plants included in PROINFA are expected to be operational by late 2007.

At present the Government is endeavouring to resolve differences between the 144 PROINFA producers in the Brazilian Association of Small and Medium Energy Producers (APMPE) and ELETROBRAS, over ownership of the carbon credits generated when the projects are made operational. While Decree No. 5025 of 2004 states that the money from carbon credits should go to the "PROINFA account" held by ELETROBRAS, APMPE is proposing that 50% should be made available to project principals.

Lastly, the same state oil company, PETROBRAS, has announced that it will generate 240 MW by means of its own renewable energy projects, mainly wind power, for an investment expected to total US$ 700 million by 2011.

The commitment in the new Government of **Chile's** Programme is to increase electricity generation using renewable energies by 15% by the year 2010. To achieve this target by promoting energy innovation and diversification and exploiting available natural resources, Chile's Production Development Corporation (CORFO) and the National Energy Commission (CNE) launched a joint call for tenders in 2005, which was the first call for small-scale renewable energy projects.

For this first call for projects, a total of 75 project tenders were received, 46 of which (70%) were approved for an initial total of US$ 1,319,210. Of the projects approved, 11 were for energy generation from biomass (forestry resources and organic waste), 12 for wind power, 22 for hydroenergy (water) and one for geothermal energy (volcanic belt). According to conservative estimates, calculated on the basis of 27 of the 46 approved projects, their installed capacity will total 140 MW.

In June 2006, CORFO and CNE launched their second joint call for projects, designed to finance some of the studies or specialist consulting during the pre-investment phase, up to a maximum of US$ 50,000 per firm, to be used for initiating feasibility studies and basic engineering studies to improve the quality of the initiatives and reduce the factors of uncertainty associated with renewable energy projects. Firms from various sectors, private individuals and legal entities were all entitled to tender projects which, while they did not necessarily have to be involved in the energy generation business, did need to be conducting investment projects in energy generation from renewable sources for amounts of US$ 400,000 or more.

From the regulatory standpoint, in July 2006 the President of Chile's Chamber of Deputies and the President of the Chilean Senate's Mining and Energy Commission tabled a motion for a bill amending the Electricity Act *(Ley General de Servicios Eléctricos)* to encourage the use of renewable energies. The motion states that, as the incentives established in Fast-Track Electricity Laws I and II *(Corta I y II)* (exemption from paying trunk-line charges and free market access) benefit projects of under 20 MW, the CNE considers projects with an installed capacity of less than 20 MW to be "renewable".

The motion therefore proposes to amend the Electricity Act in order to make it economically feasible to incorporate all means of electric power generation from non-conventional sources, establishing a separate call for tender for the 5% reserve among the generators of such sources, with price competition between them.

In 2002, **Colombia's** multi-utility company, Empresas Públicas de Medellín, launched a call for tenders to build the country's first windmill park in La Guajira (Jepírachi project), on Colombia's northern Caribbean Sea coast. This is an experimental plan, the first of several to be conducted by Colombia, which could lead to the economic development of the La Guajira desert region.

Jepírachi (which means "north-east winds" in the *wayuu* language) is an experimental wind power project, a laboratory for discovering and learning about wind power – this new, clean, renewable energy source that could become an alternative energy supply for Colombia in the future, provided that the project results confirm its viability and that it is welcomed by Colombia's electricity sector.

The successful bidder for the international call for tenders to supply wind-powered electricity generators and an electric substation for the park was the company Nordex Energy, which has been in charge of setting up the park, with technical personnel from Empresas Públicas de Medellín providing logistical support and technology training.

The Park – which cost US$ 21 million for the installation of 15 wind-powered generators with a total capacity of 20 megawatts – occupies an area of 165 hectares, 160 hectares of which comprise the protection area. The park was inaugurated by President Uribe on 6 February 2004 and is currently operational.

As it is a technological innovation project, Jepírachi obtained tax exemptions of around US$ 19,714 million from Colombia's National Council for Science and Technology (COLCIENCIAS). Also, by virtue of the agreement concluded with the Prototype Carbon Fund administered by the World Bank (WB), Empresas Públicas de Medellín has been negotiating certified CO_2 emission reductions for clean energy generating processes in the windmill park. In accordance with the Kyoto Protocol, as it will displace thermal generation, Jepírachi will reduce around 800,000 tons of carbon dioxide in 15 years, for a carbon credit value of approximately US$ 2.8 million.

The **Costa Rican** Government has developed a series of measures to encourage the incorporation of non-traditional renewable energy sources into electric power generation. The Fourth National Energy Plan (Costa Rica's energy administration (DSE), 2003) makes it national policy to maintain the use of renewable energy for electric power generation and also to keep up efforts to ensure that production costs for this public service are as low as possible, whilst taking into consideration quality, environmental and social criteria. The programme of rural electrification by conventional means is expected to reach 99% of Costa Rican families by 2010. This means that 12,000 households will still be without electricity.

For this reason, Costa Rica's national utility, the Costa Rican Institute of Electricity (ICE), with the support of the United Nations Development Programme (UNDP) and the Global Environment Facility (GEF), is implementing Phase I of the National Off-Grid Electrification Programme based on Renewable Energy Sources (project COS/02/G31). The overall aim of the Initiative, Phase I of which has a budget of US$ 2 million, is to help remove obstacles to the use of renewable energies in remote rural areas that are inaccessible to conventional extensions of the grid.

The preparatory phase of this programme determined that for 7,273 homes of the 12,000 that would still be off grid (equivalent to 329 rural communities), their relative isolation and the availability of local resources make renewable energy systems the most cost-effective alternative. For the remaining 4,700 or so homes, another type of approach will be required for electrification and they will need to be included in future plans for extending the grid after 2010. In addition, the programme brings benefits to the world environment, by mitigating an estimated 210,000 tons of CO_2 emissions in a ten-year impact analysis period. Phase I of the programme will result in an estimated reduction of 5,700 tons of CO_2 in a ten-year impact analysis period.

Phase II of the programme is currently in the GEF approval pipeline and provides for total financing of more than US$ 19 million.

In December 2005, **Ecuador's** National Electricity Council (CONELEC) approved Regulation No. 004/04, laying down the rules and prices governing the operation of any renewable energy generating plants to be set up in Ecuador, as well as the parameters for setting charges.

For price regulation and setting, CONELEC cites the following non-conventional renewable energies: wind, biomass, biogas, solar and geothermal power and small hydroelectric power plants. These prices shall remain in application for 12 years as from the date of signature of the licensing contract and up to 31 December 2006 for plants that have already signed a contract.

The following table shows the prices to be applied for power measured at the point of delivery, expressed as US cents per kWh.

TABLE 1
PRICES SET FOR ELECTRICITY PRODUCED USING THE VARIOUS RENEWABLE TECHNOLOGIES

Power plants	Price (US cents per kilowatt-hour) Mainland Ecuador	Price (US cents per kilowatt-hour) Galapagos Islands
Wind	9.31	12.10
Solar	28.37	31.20
Biomass and biogas	9.04	9.94
Geothermal	9.17	10.08
Small hydroelectric power plants up to 5 megawatts	5.80	6.38
Small hydroelectric power plants from 5 to 10 megawatts	5.00	5.50

Source: Ecuador's National Electricity Council (CONELEC) (2005).

Furthermore, power plants producing renewable non-conventional energies shall operate in the wholesale electricity market and be treated like any conventional power plant, in accordance with the regulations in force on that date. The non-profit private corporation National Energy Control Centre of Ecuador (CENACE) is obliged to give preference to dispatching to the national grid all the electrical power from power plants using non-conventional renewable resources.

These rules govern all small hydroelectric power plants with a nominal installed generating capacity of less than 10 megawatts (MW) and for plants with non-conventional renewable technology and a production capacity of up to 15 MW. For the Galapagos Islands there is a special scheme for setting the price per kilowatt-hour.

A little more than one year after it came into force, CONELEC regulation 004/04 began to produce results in terms of projects. The following table shows the renewable energy projects in the process of being approved by CONELEC.

Table 2
PROJECTS USING NON-CONVENTIONAL SOURCES

Company	Proyect	Capacity (MW) Self-generation	Sale of surpluses to (MEM)	Total	Energy source	Energy generation technology	Province	CONELEC procedure
Sociedad Agrícola e Industrial San Carlos	San Carlos (En operación)	7	28	35	Sugarcane bagasse	Steam	Guayas	Licesing Contract signed
Compañía Lucega S.A. Electric	Ecudos (En operación)	6.4	6.6	13	Sugarcane bagasse	Steam	Cañar	Licesing Contract signed
Compañía Ecoelectric S.A.	Valdez (En operación)	5.3	0.7	6	Sugarcane bagasse	Steam	Guayas	Licesing Contract signed
Villonaco Wind Power	Villonaco	0	15	15	Wind	Wind generator	Loja	Licesing Contract signed
Electroviento S.A.	Salinas	0	10	10	Wind	Wind generator	Imbabura	Licesing Contract signed
Compañía Eólica San Cristobal S.A. (EOLICSA)	San Cristóbal	0	2.4	2.4	Wind	Wind generator	Galápagos	Licesing Contrct signed
Ingenio Azucarero del Norte Compañía de Economía Mixta (IANCEM)	Tababuela (En operación)	2.2	0.8	3	Sugarcane bagasse	Steam	Imbabura	Licence Certificate Being processes
Ingenio Azucarero Valdez S.A.	Planta Industrial (En operación)	3	0	3	Sugarcane Bagasse	Steam	Guayas	License Being procesd

Source: Ecuador's National Electricity Council (CONELEC) (2006)

In **El Salvador**, the Ministry of Environment and Natural Resources, together with the Ministry of Economy (MINEC), with financial assistance from the Energy and Environment Partnership with Central America (EEP), is developing the System for the Promotion of Renewable Energies in small-scale projects (SIFER). The mechanism seeks to overcome barriers to renewable energies and to facilitate the conclusion of contracts with stable prices for periods exceeding 10 years. This mechanism offers marketing firms a guarantee of financial compensation, based on the difference between contract prices and market prices. In addition, it has a Revolving Guarantee and Stabilization Fund for Renewable Energy (FOGES) which grants financial compensation as soft loans during the term of the contract, for the same payment period as for the bank loan for this investment. FOGES was created with funds from the El Salvadorian Government and from donor countries. After that, generators pay the loan granted by the Fund.

Lastly, the SIFER scheme provides partial guarantees for the loan (up to 25% of the bank loan) and funding for feasibility studies. At present, the design of the SIFER promotion instrument is now complete and proceedings are under way to secure funding to make it operational.

In addition to the SIFER initiative, in February 2006 El Salvador's Ministry of Economy presented the Draft Bill on Tax Incentives for the Promotion of Renewable Energies, which forms part the new energy policy. Technical discussions on this tax incentive legislation are still ongoing. The bill will shortly be submitted to the Legislative Assembly for promulgation. Amongst other benefits, the bill includes an exemption from import duties on goods and facilities for installing energy generation plants within El Salvador. The Government's objective is to achieve a 20 MW increase in renewable resources by means of new private projects for wind, solar and biomass energy and for mini-hydroelectric power plants over the next five years. The bill would earmark incentives solely for new and small investments, meaning that the law would exclude major investments such as those of El Salvador's state geothermal company LaGeo or the state electricity utility, River Lempa Hydroelectric Executive Commission (CEL).

Neither SIFER nor the Tax Incentives Act has yet been implemented in El Salvador. In the case of SIFER, the financing for the fund's capitalization is still being negotiated, whilst the Tax Incentives Act is still under discussion with the Ministry of Finance, meaning that it must then be approved by the Legislative Assembly.

Also worthy of mention is the inauguration in May 2006 of the new geothermal plant at the Berlin power plant belonging to state geothermal company LaGeo, designed to add a further 40 MW of capacity. LaGeo has invested US$ 90 million in the "Berlin Expansion" project. The project comprises three major components: boring 10 wells, including production wells and reinjection wells, the conceptual design of equipment, the manufacturing and assembly of the third generating plant by GE-Nuovo Pignone and the civil engineering and haulage systems, which are also under construction by ENEL Produzione SpA with technical support from LaGeo. The project is currently 75% complete and is expected to come into operation in September 2006.

In **Mexico**, the Chamber of Deputies approved the Law on the Use of Renewable Energy Sources (LAFRE) in December 2005. Among other instruments, the law provides for the creation of a trust worth an annual US$ 55 million to ensure that renewable energies attain 12% of domestic energy generation by 2012. Mexico's Energy Ministry will play a crucial role in implementing this law. Also, in its role as governing body of the country's energy policy and planning, the Energy Ministry will continue to coordinate, integrate and promote energy policies and programmes for promoting these alternative energy sources.

As regards allocating the trust fund, the Law stipulates that federal funding contributions should be allocated as follows during the first year of operation:

- 55% for the Green Fund, which encourages the use of mature renewable technologies (electrical applications).
- 6% for the Emerging Technologies Fund (electrical applications).
- 10% for the Rural Electrification Fund.
- 7% for the Biofuels Fund.
- 7% for the General Renewable Energy Fund (non-electrical applications).
- 15% for the Fund for Renewable Energy Research and Development (FIDTER).

LAFRE has yet to be approved by the Senate, which will happen once the new congress begins ordinary sessions in September 2006. Should LAFRE be approved, the Energy Ministry is obliged to present the programme establishing specific goals and objectives, strategies and actions, and including an updated inventory of renewable energy sources, so as to ensure presidential approval within a period of nine months as from the date of publication of LAFRE.

As regards new projects, in 2005 Mexico's Federal Electricity Commission (CFE) started to build the country's first large-scale wind power plant (83 MW) in La Venta, Oaxaca, which will come into operation in October 2006. The Energy Ministry plans to build a further 505 MW of wind power capacity in the same region over the coming years (under an independent power-producer scheme), which is expected to increase installed capacity to 588 MW by 2014. To date, Mexico's Energy Regulatory Commission (CRE) has granted seven licences for private self-sufficiency projects using wind power technology, which will add a total of a little over 950 MW to Mexico's National Electricity System (SEN) over the coming years

In order to promote the development of private self-sufficient energy projects using intermittent renewable energies, in January 2005 the CRE approved amendments to the model interconnection contract applicable to this type of energy source, defining the concessionaire's "self-sufficiency capacity" as the average capacity measured at the interconnection point. This is a regulatory instrument that considers the intermittent availability of the primary energy resource. The components of such instruments include: wind and solar energy and hydroelectricity with water storage or limited availability. These instruments enable energy self-sufficient plants to feed the power they generate into the supplier's transmission grid, when the primary energy is available, for distribution to its consumer centres as required.

By late 2005, the CRE had granted 54 licences for electrical power generation from renewable sources in the self-sufficiency, cogeneration and export categories, 37 of which are already up and running. The others are expected to come into operation in 2007, which will add more than 1,400 MW of renewable energy capacity to the grid, and generate a total of more than 5,000 gigawatt-hours (GWh) per year.

In mid-2005, the **Nicaraguan** Government ratified two important laws to promote the renewable energy sector. The Law for the Promotion of Electric Power Generation using Renewable Sources (Law No. 532 of April 2005) stipulates that all projects must comply with the national energy policy and must diversify the country's energy supply. In addition, the law stipulates a ten-year period of tax benefits for investing firms as from the law's publication date.

One of the most important incentives is a seven-year income tax exemption as from the project's date of entry into commercial operation. There is also an exemption from value added tax for some types of equipment and machinery. In addition, investing firms are released from paying municipal taxes on some types of immovable property for a ten-year period. According to some analysts, the exemptions provided for under the law will cut initial investment costs by between 15% and 20%.

In addition, the law will guarantee payment of between US cents 5.5 and 6.5 per kWh for energy from renewable sources. Whilst this will facilitate investments, since it will make investment cost calculations more reliable, it is not particularly attractive to some investors because earnings are capped at 6.5 US cents/kWh. The electricity produced from renewable sources will be authorized for sale to other countries only after Nicaragua's demand is met.

In May 2005, Nicaragua's Parliament reformed the Law to promote the Hydroelectric Subsector, authorizing the Ministry of Development, Trade and Industry (MIFIC) to grant licences for the use of water to generate between 1 MW and 30MW of hydroelectric power.

In March 2006, the Board of Executive Directors of the World Bank approved a US$ 50 million loan for **Peru**, in addition to a US$ 10 million donation from the Global Environment Facility (GEF), to increase access to efficient and sustainable electricity services in rural areas. The fixed-margin loan must be reimbursed within ten years and provides for a grace period of 11.5 years.

The project to be developed to promote these services will be implemented by Peru's Ministry of Energy and Mines, with the aim of providing electricity services to households and firms in rural areas that currently lack access to modern energy sources. In addition, the project will adopt an integrated approach to rural electrification that should lead to the construction of an efficient and effective system for the provision of electricity services to Peru's rural areas.

The project will support the following specific activities:

- Subsidies targeted at public and private electricity service-providers that invest in rural electrification subprojects with conventional or renewable sources of electricity. These subprojects will provide around 160,000 new rural connections to households, firms, health centres, schools and community centres for the benefit of some 800,000 people.

- Technical assistance to support the implementation of the proposed rural electrification plan. This includes subcomponents for improving the regulatory environment, building project participant capacity, fostering private sector investment and promoting renewable sources of energy.
- To finance a pilot programme to promote the use of electricity for production. This will help to increase the productivity of rural firms by concentrating on firms that currently use diesel power, as well as on other energy-intensive agricultural and non-agricultural firms that would benefit from electrical power.
- To create a service for financing small hydroelectric power plants to provide funds during the construction and initial operation phase of small hydroelectric power plants connected to the grid, which would sell energy to the interconnected grid.

In terms of regulations, the Implementing Regulations for the Framework Law on Geothermal Resources (Law No. 26848 of 1977) were published in July 2006. This law was approved and published in July 1997 but had not been implemented up to then owing to a lack of regulations on its principles and operation. This delay was due in part to the impetus given in recent years to the development of hydroelectric projects and natural gas projects in the Camisea field, which are more completive than other energy options for electricity generation. It is hoped that the entry into force of the implementing regulations for Law No. 26848 will at last promote the exploration and development of some of the 300 available thermal areas in Peru, especially those located in the high-temperature geothermal region of Tutupaca and Challapalca, in the far south of Peru.

In the **Dominican Republic**, the Law on Incentives for the Development of Renewable Energy Sources and its Special Regimes was presented to the Congress of the Dominican Republic for approval and promulgation in 2005.

The bill guarantees a 100% tax exemption for machinery, equipment and accessories imported by firms or individuals. In addition, it provides for a ten-year income tax exemption for firms, allows firms to set 50% of their investment in the self-supply of renewable energies against income tax and guarantees dispatch priority and market quotas for renewable energies.

The bill constitutes the basic normative and regulatory framework which must be applied nation wide in order to encourage and regulate the development of, and investment in, projects using any type of renewable energy.

The Law on Incentives, which had been unanimously approved by all sectors in the Dominican Republic (Congress of the Republic, production sector, Government and other interested sectors), was submitted to the Congress of the Republic by President Leonel Fernández himself in August 2005, although it has not yet been approved. National analysts believe there is a chance that the law will be approved by late 2006.

Laws 112-00 on hydrocarbons and 125-01 on electricity had already been promulgated in 2000 and 2001 respectively, creating a number of incentives for the development of renewable energy sources. However, they were not enough to promote the sector.

In July 2006, the Government of **Uruguay** presented a bill to the General Assembly for promoting and regulating the production, marketing and use of agrofuels in the following categories:

- Ethanol (anhydrous and hydrous).
- Biodiesel (mono-alkyl esters of fatty acids).

The bill instructs the National Administration for Fuels, Alcohol and Cement (ANCAP) to incorporate domestically-produced alcohol fuel in a proportion of up to 5% of the total volume of all alcohol fuel/gasoline mixtures for use in motor vehicles that are sold on the domestic market up to 31 December 2014.

The bill also instructs the ANCAP to incorporate domestically-produced biodiesel in a proportion of up to 2% of the total volume of the biodiesel/diesel oil mixture for use in motor vehicles that are sold on the domestic market up to 31 December 2011. This compulsory minimum will be increased to 5% after January 2011.

Uruguay's Ministry of Industry, Energy and Mining will authorize biodiesel production by plants with a maximum production capacity of 4,000 litres per day. Firms producing biodiesel and alcohol are eligible for the following benefits:

- Exemption from wealth tax on capital assets.
- 100% income tax exemption for the first five years.
- 50% income tax exemption after the first five years.

ANCAP will be responsible for blending the composite fuels (biodiesel + diesel oil or gasoline + alcohol). According to recent statements from a number of government representatives, the bill is very likely to be approved during the second half of 2006.

With regard to projects for generating electrical power from renewable sources, in 2005 a call for tenders was launched for the incorporation of distributed generation, which was awarded to a 4.05 MW wind power generation project. However, the contract has still not been signed and so 46 MW will not be awarded until mid-2006.

In March 2006, the President of the Republic issued decree 77/006 authorizing Uruguay's National Electric Power Generation and Transmission Administration (UTE) to conclude special power purchase contracts with national providers producing energy from wind, biomass or small hydroelectric power plants. The total installed capacity will not exceed 60 MW, with the initial target being to assign 20 MW to each type of energy source.

"Renewable" capacity will be incorporated into the grid by means of a competitive tendering procedure. The contract will be awarded taking into account the tendered price per unit of energy delivered, as well as the lead times and other technical parameters. UTE will pay the corresponding price for the power, establishing the delivery means and measures in an operational agreement. The contract term will be up to 20 years as from the date of the power plant's entry into service. The tenders for the competitive tendering process established by decree 77/006 are planned to be opened in September 2006.

As regards multilateral and subregional advances in renewable energies, **Central American Energy and Environment Ministers** have made major efforts in the past two years. At the First Meeting of Ministers of Environment and Energy of Central America, held in Honduras in February 2005, government representatives signed the "San Pedro Sula Declaration" on energy and the environment, in which they expressed the political will to define the energy sector's role as a key instrument for poverty reduction in the region. They also agreed to define an integrated vision in the common principles of the Central American Alliance for Sustainable Development (ALIDES) to provide political support for promoting the use of renewable energies in the Central American region.

The San Pedro Sula Declaration instructed the Executive Secretariat of the Central American Commission on Environment and Development (CCAD) (which belongs to the Central American Integration System (SICA)), together with international cooperation agencies, to ensure that the Economic Commission for Latin America and the Caribbean (ECLAC) and the Central American Bank for Economic Integration (CABEI) participate in and support energy sector initiatives for the promotion of renewable energies in the region. It also agreed to request the CCAD to draw up a draft regional plan to comply with the Johannesburg mandate.

One year later, at the Second Meeting of Ministers of Environment and Energy of Central America in San Salvador in February 2006, government representatives agreed to sign the "San Salvador Declaration", which contains instructions on incentives for promoting sustainable energy in Central America, including:

- To promote a cross-sector approach between energy policy and environment policy institutions in order to develop a regional energy policy.
- To support the development of a regional energy policy.
- To promote efforts towards a Strategy for Regional Energy-Efficiency Policy to help to reduce foreign exchange spending and enhance the competitiveness of the various sectors.
- To support initiatives for seeking financing with a view to implementing the actions recommended in the Strategy for Regional Energy-Efficiency Policy.

The Ministers made the CCAD responsible for following up the above agreements.

The **Energy and Environment Partnership with Central America** (EEP) is an initiative of the United Nations World Summit on Sustainable Development in Johannesburg in 2002, proposed by Finland's Ministry for Foreign Affairs, the CCAD and the General Secretariat of SICA. The objective of the EEP is to ensure that more renewable energies are used to meet Central America's energy requirements, thereby contributing to its sustainable development and helping to stem the increase in, and mitigate the adverse effects of, world climate change.

The Partnership provides non-reimbursable grants to project developers (governmental institutions, private enterprise, communities and non-governmental organizations) for feasibility studies or to develop pilot projects, for amounts ranging from 20,000 to 50,000 euros. To date, the programme has paid out more than 3 million euros to implement 77 projects in the seven countries of the subregion (three projects in Belize, four in Costa Rica, 12 in El Salvador, 12 in Guatemala, 11 in Honduras, seven in Nicaragua and 12 in Panama, in addition to 16 regional projects).

Chapter II
Status and trends in the share of renewables in the region

Annex 1 describes the basic concepts and methodology used to calculate the total energy supply (TES) and the "renewability fractions" analysed in this chapter, using the same work methodology as for the document on renewable energies which ECLAC had presented to the Bonn Conference.

II.1 Comparative analysis of total energy supply in Latin America and the Caribbean (2002-2004)

Based on the methodology and concepts described in Annex 1, the information on 26 Latin American and Caribbean countries has been updated for 2004[3] in order to compare it with the 2002 data presented in the above-mentioned publication.

The information was analysed on both an individual and subregional basis for each country. The countries have been grouped into subregions based on the information available in the Energy Economic Information System (SIEE) of the Latin American Energy Organization (OLADE), as well as on the common geo-economic areas to which the countries belong. This led to the following subregions being defined:

- **Central America:** Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua and Panama.
- **Caribbean Subregion 1** (or Eastern Caribbean): Barbados, Granada, Guyana, Jamaica, Trinidad and Tobago, and Surinam.

[3] It was decided to work with statistical information from the Energy Economic Information System (SIEE) of the Latin American Energy Organization (OLADE) for 2004 and not to take into consideration information for 2005, since there are certain discrepancies with data from the 2005 national balance sheets for some countries. See website: http://www.olade.org.ec/php/index.php?arb=ARB0000168

- **Caribbean Subregion 2** (or Greater Antilles): Cuba, Haiti and Dominican Republic.
- **Andean Community**: Bolivia, Colombia, Ecuador, Peru and the Bolivarian Republic of Venezuela.
- **Expanded MERCOSUR**: Argentina, Brazil, Paraguay, Uruguay and Chile.

In addition, Mexico and Brazil are analysed individually in some instances, on account of the size and special characteristics of their energy systems.

In the case of the Caribbean subregion, two points must be taken into account: (i) all the countries analysed provide information to the OLADE Energy Economic Information System, which guarantees standardized processing of information and allows it to be compared; and (ii) the subregion has been subdivided into two units of analysis (Caribbean Subregions 1 and 2), based on differences in their natural resource endowment and on socio-economic factors.

The reason for analysing the share of renewable sources by subregion is to show the potential of each group of countries and to use this as a basis for increasing the share of renewable sources in national and regional energy structures.

This means that, in addition to efforts by individual countries to improve their use of renewable sources, subregional results are obtained from implementing various initiatives: technology exchange; cooperation to assist isolated communities; integration of energy structures to achieve minimum targets; and the development of accounting methods and mechanisms for exchanging renewable energy certificates.

The results of the study on the share of renewable sources in each subregion's total energy supply are analysed below, comparing the results for 2002 with those for 2004.

(A) Latin America and the Caribbean

A comparison of data for 2002 and 2004 shows that the relative shares of fossil and renewable natural resources in Latin America and the Caribbean's total energy supply did not change significantly over the period. Renewable resources represent approximately 25% of the region's total energy supply (see figure 1).

As regards hydrocarbons, even though the share of natural gas had risen as high as 28.3% of TES in the region in 2002, two years later it had fallen by 13% owing, amongst other factors, to the growth in the oil supply (+4% compared with 2002). This might lead to the conclusion that the region is not set on a "virtuous energy path", as would be the case if there had been an increase in environmentally cleaner hydrocarbon energy like natural gas.

However, this initial conclusion needs to be treated with caution. A glance at the countries' TES data shows that the "regional analysis" is heavily influenced by the large increase in oil supplies in the Bolivarian Republic of Venezuela (+54% compared with 2002) and by a steep reduction in the supply of natural gas in the same country (-23% compared with 2002). In all the other countries and subregions (excluding the Andean Community of course) the trend is reversed, although the heavy impact of a hydrocarbon-rich country like the Bolivarian Republic of Venezuela distorts the overall interpretation of trends.

The share of coal in TES increased by 84% compared with 2002, owing to a significant increase in supply in Mexico, Costa Rica and the Dominican Republic. The share of nuclear energy exceeded 1% for the first time, owing to substantive input from the Angra II power plant in Brazil.

The trend in the share of renewable sources was down slightly, with a 3.5% drop from 25.7% in 2002 to 24.8% in 2004. This indicates that the significant advances which many countries in the region have made in the renewable energy sector in recent years (in terms of both regulations and project implementation), have still not been reflected in a change on the ground, that is to say, in the share of renewable sources in the energy structure.

The downturn in renewable energies stems chiefly from a sharp decrease in hydroelectricity supply (-23% compared with 2002), particularly in Brazil, Uruguay, Colombia and Mexico. There was also a drop in the supply of both geothermal energy (the growth of which has stagnated over the past five years, particularly in Mexico) and sustainable residential fuelwood. The supply of cane products has increased (+21% compared with 2002, primarily owing to steady growth in the production of bioethanol in Brazil), as has that of other renewable energies, the share of which has risen sharply mainly as a result of new wind power projects in countries like Brazil, Jamaica and Costa Rica.

A point worthy of note is that the calculation of renewable energy sources does not include data on the use of modern technologies like solar energy for agricultural drying or in isolated solar energy systems. This is because in conventional energy balance sheets they are still not considered to have significant or useful potential.

FIGURE 1 - A
LATIN AMERICA AND THE CARIBBEAN – 2002 – ENERGY SUPPLY

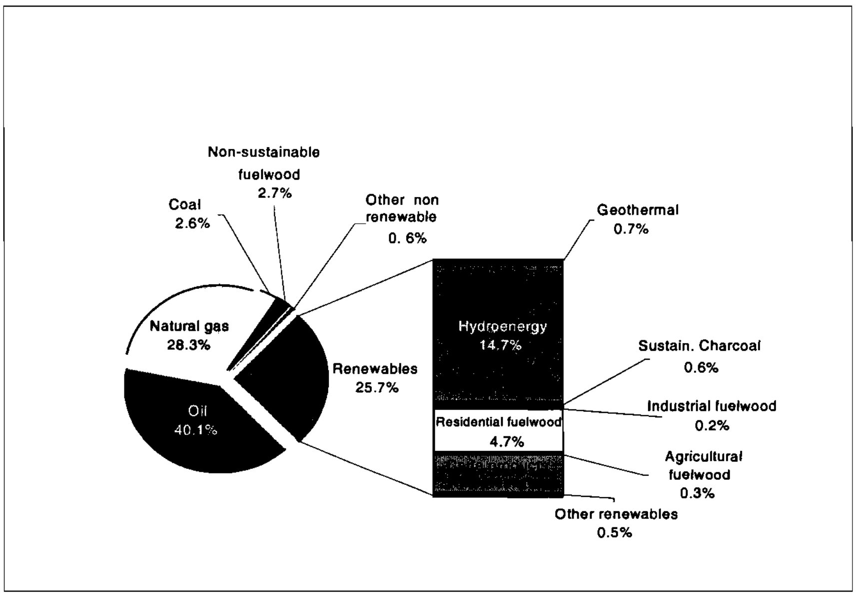
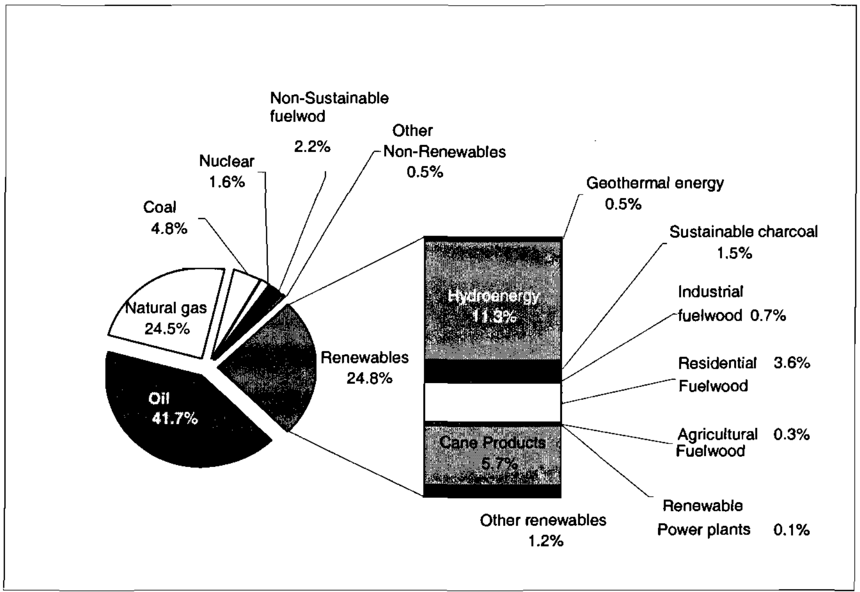


FIGURE 1 - B
LATIN AMERICAN AND THE CARIBBEAN- 2004 ENERGY SUPPLY



Source: Author, based on data from the Energy Economic Information System (SIEE) of the Latin American Energy Organization (OLADE).

(B) Central America

Oil continues to represent a share of around 50% of Central America's total energy supply, although there was a slight drop of 2.5% between 2002 and 2004, confirming a significant dependency on imported hydrocarbons. This takes on special importance when countries are net importers of hydrocarbons (see figure 2).

From the environmental standpoint, there was a marked increase in coal supplies (particularly in Costa Rica) of 23% compared with 2002 (rising from 1.7% of total energy supply in 2002 to 2.1% in 2004).

In the Central American subregion, renewable sources continue to make a very large contribution to total energy supply, with an increase, albeit slight, since 2002. The share of hydropower increased (particularly in Guatemala and Costa Rica), as did geothermal energy (owing mainly to the entry into operation of new plants in El Salvador and higher productivity from the Costa Rican fields).

The portion of non-sustainable biomass fell slightly (from 14.7% in 2002 to 14.1% in 2004), which confirms serious concerns about the efficiency and sustainability of fuelwood use in the countries of the region. This should foster the development of projects and research on the subject, which could be put forward in various international cooperation spheres.

FIGURE 2A
CENTRAL AMERICA - 2002 - ENERGY SUPPLY

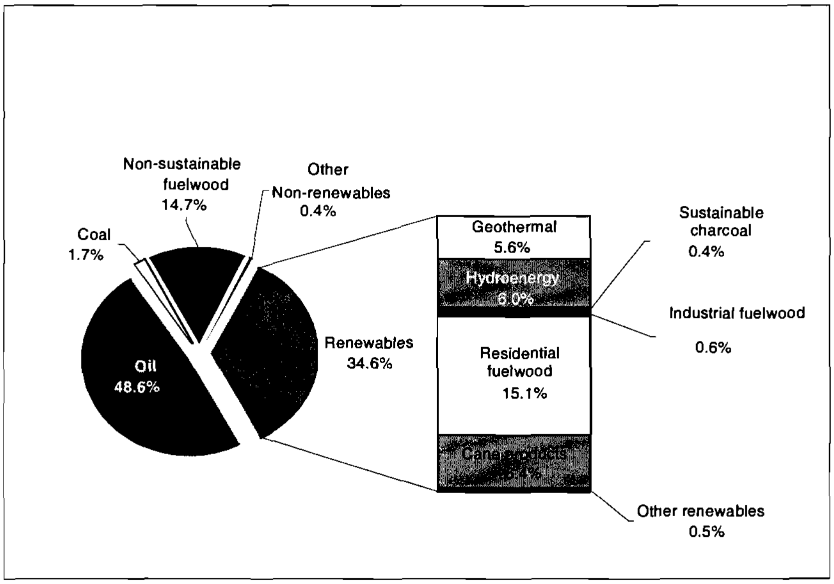
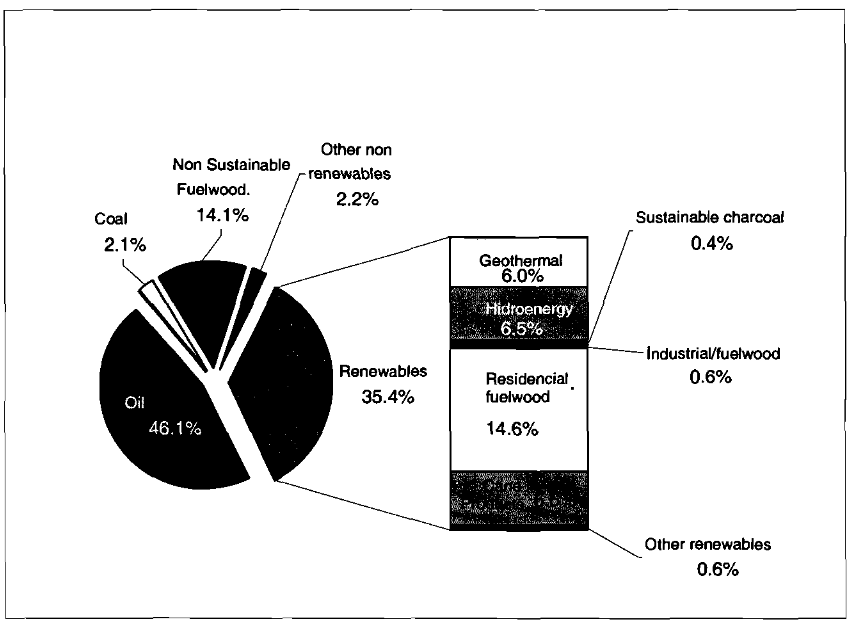


FIGURE 2B
CENTRAL AMERICA - 2004 - ENERGY SUPPLY



Source: Author, based on data from the Energy Economic Information System (SIEE) of the Latin American Energy Organization (OLADE).

(C) Mexico

In Mexico, hydrocarbons continue to play a dominant role in the country's energy supply, exceeding 80% of TES. However, its hydrocarbons mix presented positive environmental trends between 2002 and 2004, since the share of natural gas increased by 21% compared with 2002, as opposed to an 8% reduction in the oil supply (see figure 3).

As a result of this stability in the total percentage supply of hydrocarbons, the contribution of all renewable sources to TES continues to be very small (9.5%), below the 10% threshold proposed by the Brasilia Platform.

Renewable energy sources include significant supplies of hydroenergy and sustainable residential fuelwood, although the share of both fell by 12% and 10% respectively compared with 2002. The percentages of geothermal energy and renewable non-fuelwood biomass (cane products) continue to be very small (1.0% and 1.3% respectively).

As efforts and programmes for using renewable energies like solar and wind power are still very recent, their share of energy generation is practically nil.

FIGURE 3 - A
MEXICO, 2002 ENERGY SUPPLY

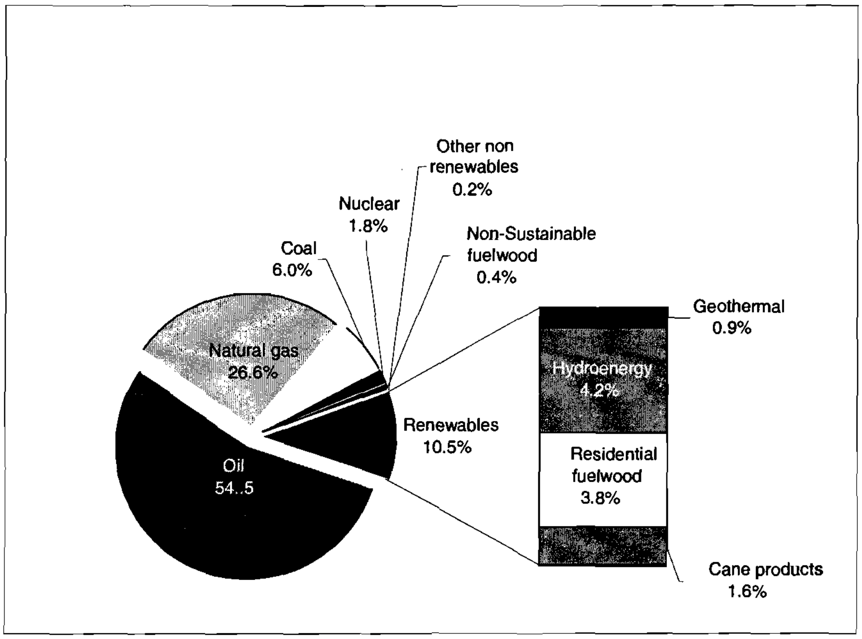
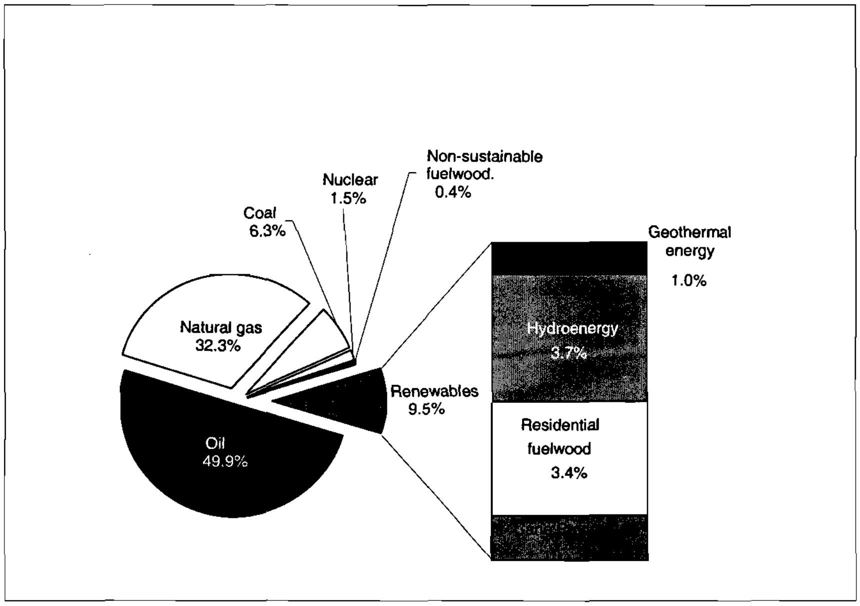


FIGURE 3 - B
MEXICO, 2004 ENERGY SUPPLY



Source: Author, based on data from the Energy Economic Information System (SIEE) of the Latin American Energy Organization (OLADE).

(D) Caribbean Subregion 1

The countries in this subregion continue to have one of the highest hydrocarbon dependency rates in Latin America and the Caribbean (94.4%).

Given the subregion's natural resource endowment and the short time that has elapsed for commercial-scale renewable energy projects to be implemented, the share of renewable sources in TES continues to be extremely small (4.8%, with no major changes compared with 2002). All in all, it is the lowest share in the entire region and far below the 10% threshold proposed by the Brasilia Platform. Cane products continue to dominate the supply of renewables, with 2.2%, together with residential fuelwood, with 1.4% (see figure 4).

The subregion is a net hydrocarbon importer, except for Trinidad and Tobago, which is a natural gas exporter, and Barbados, which supplies some of its own oil and gas requirements. Also, electrical power generation is highly concentrated in thermal power plants, which leads to considerable pressure on imported fuels like diesel and fuel oil.

In view of all this, it is recommended to focus more effort on promoting public policies to increase the sustainability of the energy system.

FIGURE 4 - A
CARIBBEAN - SUBREGION 1: 2002 ENERGY SUPPLY

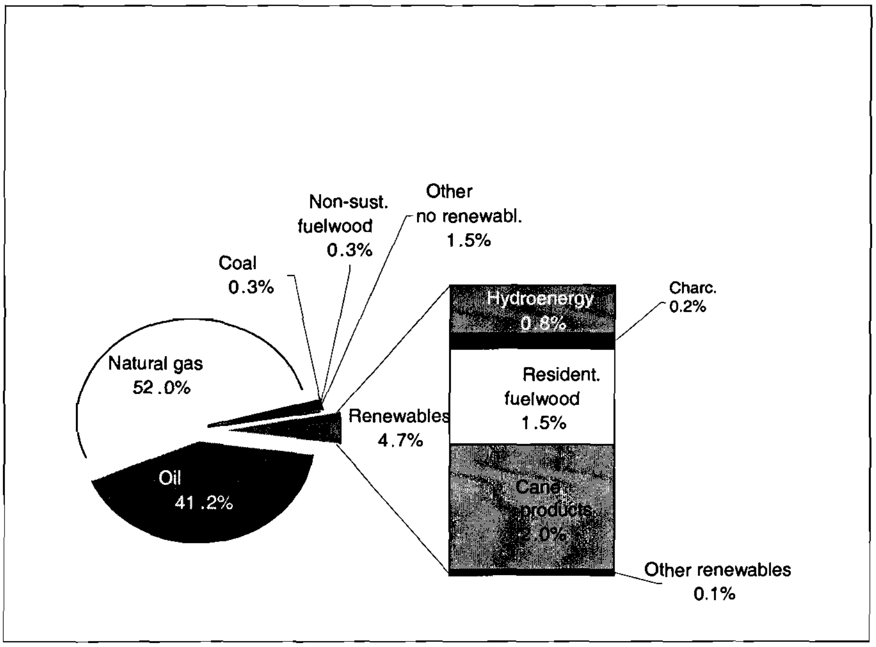
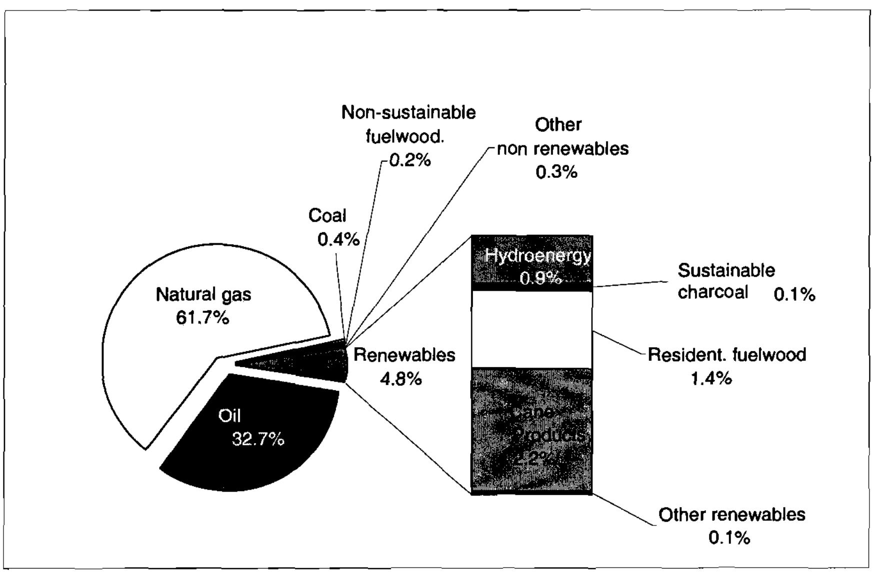


FIGURE 4 - B
CARIBBEAN - SUBREGION 1: 2004 ENERGY SUPPLY



Source: Author, based on data from the Energy Economic Information System (SIEE) of the Latin American Energy Organization (OLADE).

(E) Caribbean Subregion 2

Even though the countries in Caribbean Subregion 2 (Cuba, Haiti and the Dominican Republic) have similar socio-economic characteristics, their energy development trends and situations vary.

Haiti is a country that has always suffered a dramatic shortage of natural energy resources to which, needless to say, the energy sector has not been able to attract new investments to improve prospects. This has forced decision-makers to adopt a demand-management policy. In addition, the high level of environmental degradation hampers all efforts to improve the quality of life. Even though there are multiple causes for this degradation, the predominant factor continues to be deforestation, which affects agriculture and hydroenergy production.

Through a process of reform and capitalization of state corporations, the Dominican Republic has successfully channelled a large percentage of foreign direct investment towards a number of non-traditional sectors of the economy, including electricity generation and distribution.

In Cuba, where access to commercial energy sources has continued to increase, with 95% of the population provided with electricity, it was possible to substantively reduce the coefficient of imported energy, owing to the development of domestic sources, including renewable energies, and to greater energy efficiency.

A comparison of domestic performance in Caribbean Subregion 2 between 2002 and 2004 confirms a heavy dependency on oil, even though its supply diminished by 3% compared with 2002, owing mainly to shrinking oil supplies in the Dominican Republic. There continues to be a small share of natural gas, whereas there was a proportionally large increase in coal of 130% compared with 2002 (see figure 5), mainly stemming from the entry into operation of new coal plants in the Dominican Republic.

The share of renewable sources is significant (23.3% of TES), and is slightly up on 2002 (see figure 5). This growth stems chiefly from the increased availability of hydroenergy (particularly in the Dominican Republic) and of sustainable fuelwood for both industry and the residential sector.

Just as in other subregions, the contribution of new technologies for generating renewable energies like solar and wind power is very small. However, countries like Cuba and the Dominican Republic are making serious efforts in this area and this could lead to excellent results in the medium term.

FIGURE 5 - A
CARIBBEAN - SUBREGION 2 - 2002 ENERGY SUPPLY
(CUBA, DOMINICAN REPUBLIC, HAITI)

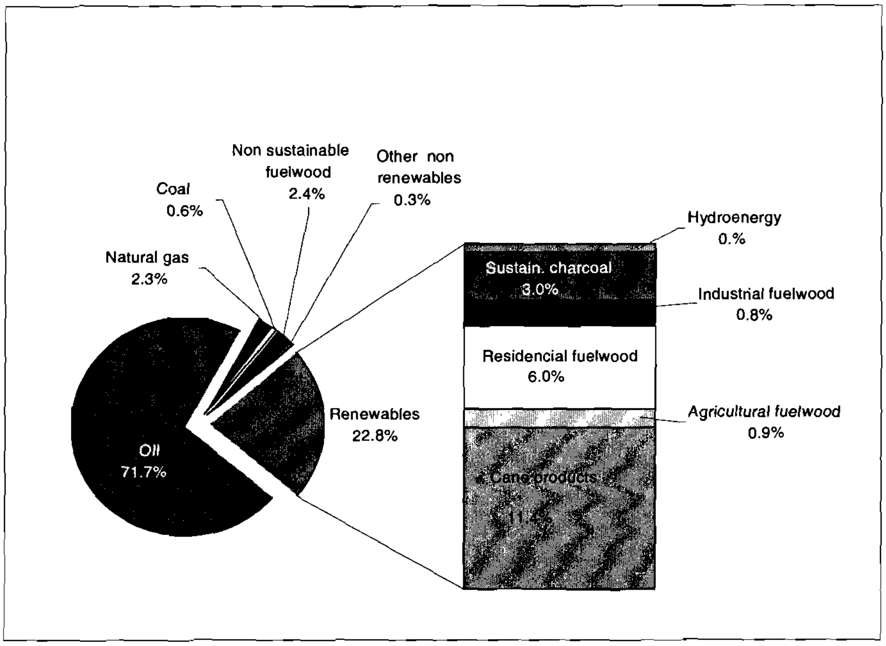
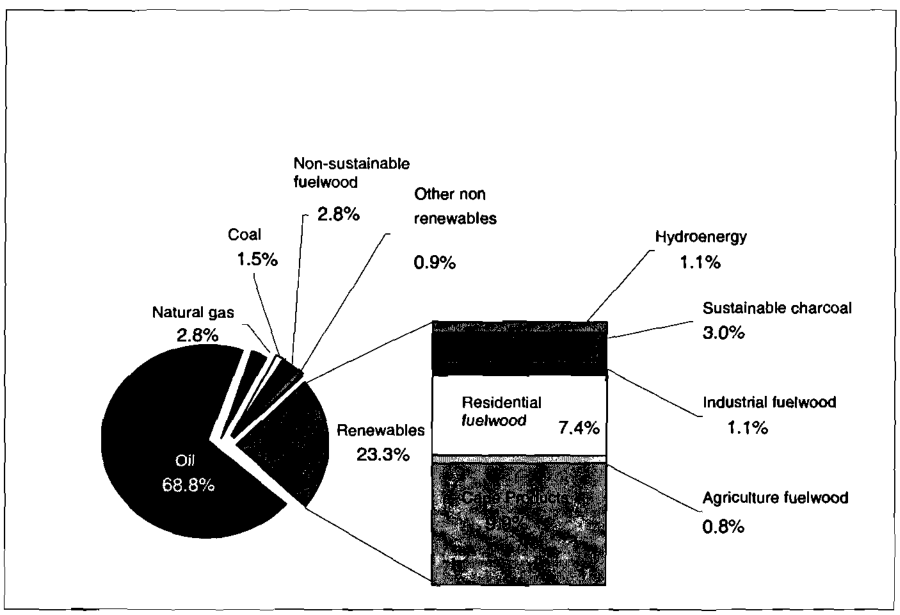


FIGURE 5 - B
CARIBBEAN - SUBREGION 2 – 2004 - ENERGY SUPPLY
(CUBA, DOMINICAN REPUBLIC, HAITI)



Source: Author, based on data from the Energy Economic Information System (SIEE) of the Latin American Energy Organization (OLADE).

(F) Andean Community

There are considered to be abundant renewable energy resources in the Andean region, although they have not all been discovered yet, nor thoroughly evaluated.

Fossil fuels continue to represent a large share of total energy supply (70.9%, much the same as in 2002). However, the supply of oil increased by 19% compared with 2002 (owing mainly to the sharp increase in oil in the Bolivarian Republic of Venezuela). By contrast, there was a significant reduction in natural gas and coal (see figure 6).

This would appear to confirm a change in the energy mix compared with 2002, since in 2002 natural gas was the most commonly used energy source, followed by oil and hydroelectricity. However, this interpretation should be qualified by the fact that there was such a large drop in the supply of gas in the Bolivarian Republic of Venezuela (-23% compared with 2002) that the increase in the supply of gas in Colombia, Peru and Bolivia was not enough to offset it.

Renewable energy sources represent 26.4% of TES, that is to say 1.5% less than in 2002. Among renewable sources, as was hoped, the share of hydroenergy increased by 1% within the total renewable portion. This rise stems chiefly from an increase in the supply of hydroelectricity in Colombia. The reduction of the renewable portion in TES is mainly the result of a drop in the share of cane products (-30% compared with 2002) and of residential fuelwood (-35% compared with the same year).

FIGURE 6 - A
ANDEAN COMMUNITY – 2002- ENERGY SUPPLY

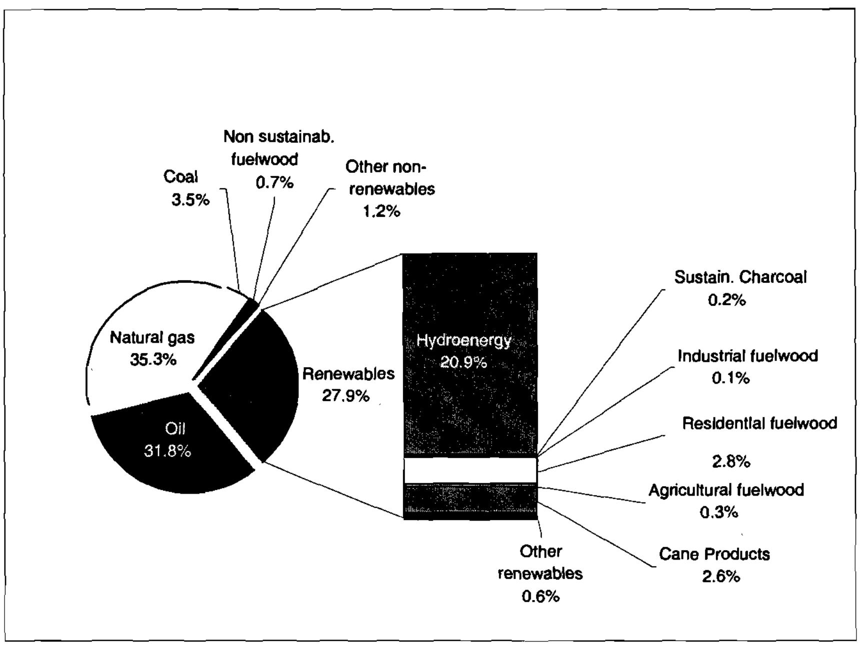
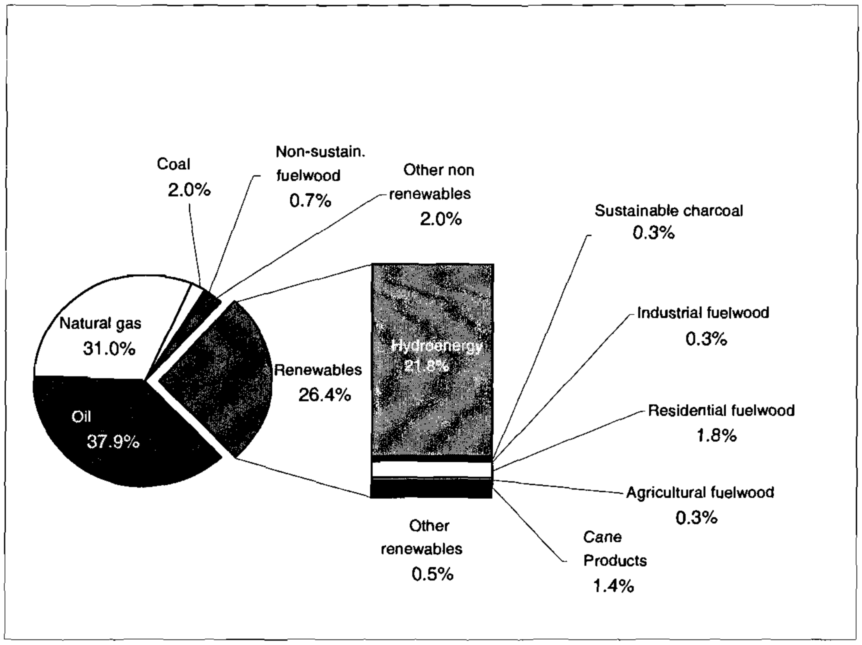


FIGURE 6 - B
ANDEAN COMMUNITY – 2004- ENERGY SUPPLY



Source: Author, based on data from the Energy Economic Information System (SIEE) of the Latin American Energy Organization (OLADE).

(G) Expanded MERCOSUR

Even though the MERCOSUR countries have similar socio-economic characteristics, their energy development trends and circumstances vary.

To a large extent, the overall joint TES for this group of countries resembles that of the Andean Community: (i) there is heavy dependency on fossil fuels (62.6%); (ii) renewable energies represent approximately one third (32.1%) of TES and (iii) a significant proportion of the hydroelectricity supply is generated by large power plants (see figure 7).

Another similarity with the Andean Community is that the potential of modern renewable technologies, especially geothermal energy and mini- and small hydroenergy stations, is very promising, although they have not yet been exploited to the full. Wind power was still not included in the energy accounting matrix for 2004 since production is marginal.

However, the expanded MERCOSUR region differs from the Andean Community in terms of the availability of certain energy sources. For instance, the share of oil diminished (-8% compared with 2002), whereas that of natural gas increased (+13% compared with 2002), mainly owing to increased gas supplies in Brazil, Argentina and Uruguay. There was a significant increase in nuclear electric power (+136% compared with 2002), stemming from the substantive contribution of the Angra II nuclear energy plant in Brazil.

The share of renewable energies in TES has fallen very slightly (-0.5%). Within the renewables portion, it is hydropower that has declined the most because of a significant shrinkage in Brazil and Uruguay's hydroenergy supplies. By contrast, the share of cane products increased by 8% compared with 2002, driven mainly by the strong expansion of Brazil's alcohol industry.

FIGURE 7 - A
EXPANDED MERCOSUR – 2002 ENERGY SUPPLY

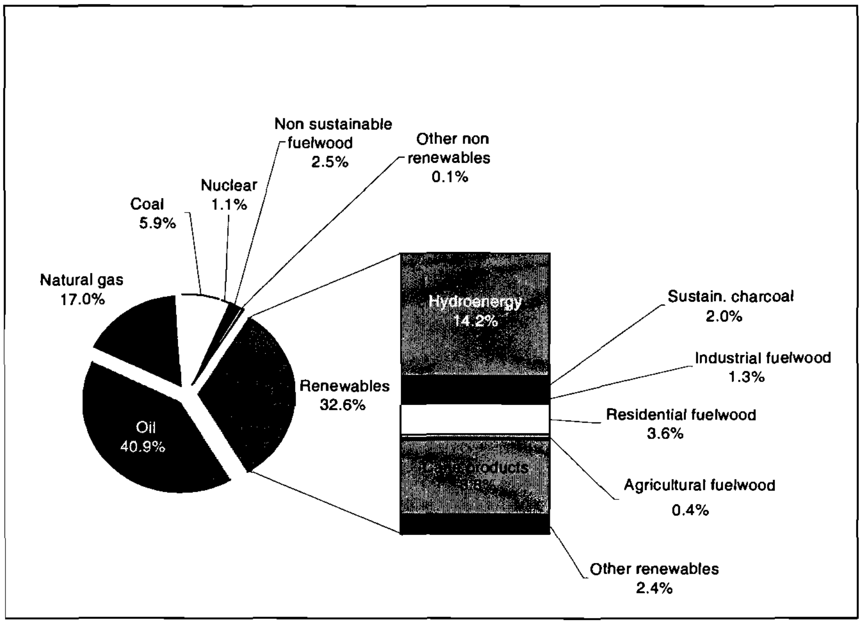
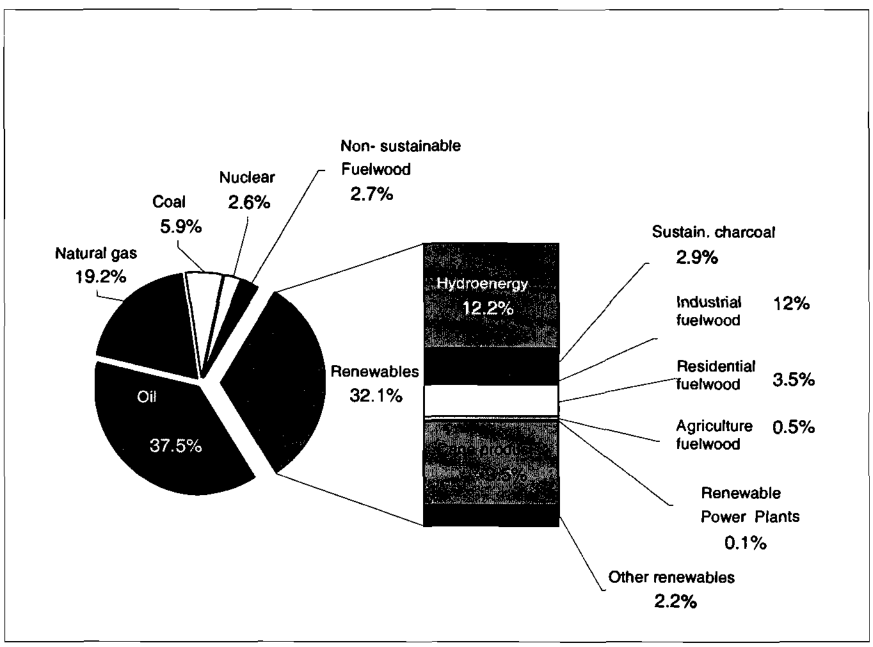


FIGURE 7 - B
EXPANDED MERCOSUR – 2004 ENERGY SUPPLY



Source: Author, based on data from the Energy Economic Information System (SIEE) of the Latin American Energy Organization (OLADE).

(H) Brazil

An analysis of Brazil's total energy supply in 2004 shows that the country continues to depend heavily on oil (37.4% of TES), although oil dependency fell by 12% compared with 2002.

The availability of Bolivian gas increased the supply of natural gas in the period from 2002 to 2004. The situation was similar with nuclear electric power, the supply of which increased greatly in percentage terms thanks to new input from the Angra II nuclear plant.

Unlike in MERCOSUR, the share of renewable energy sources in Brazil increased during the 2002-2004 period, but only by 3%. Similarly to MERCOSUR, Brazil's hydroenergy share decreased (as 2004 was a "drier" year than 2002 in terms of rainfall), whereas there was a substantial increase in the proportional share of cane products (+1.1% compared with 2002). Also, the shares of renewable fuelwood and charcoal rose slightly.

The share of other renewable energy sources like wind and solar power was still very low in 2004. However, this situation could change substantially when the new renewable energy projects promoted by the PROINFA programme enter into operation, in particular when the large windmill parks in southern Brazil become fully operational.

FIGURE 8 - A
BRAZIL- 2002 – ENERGY SUPPLY

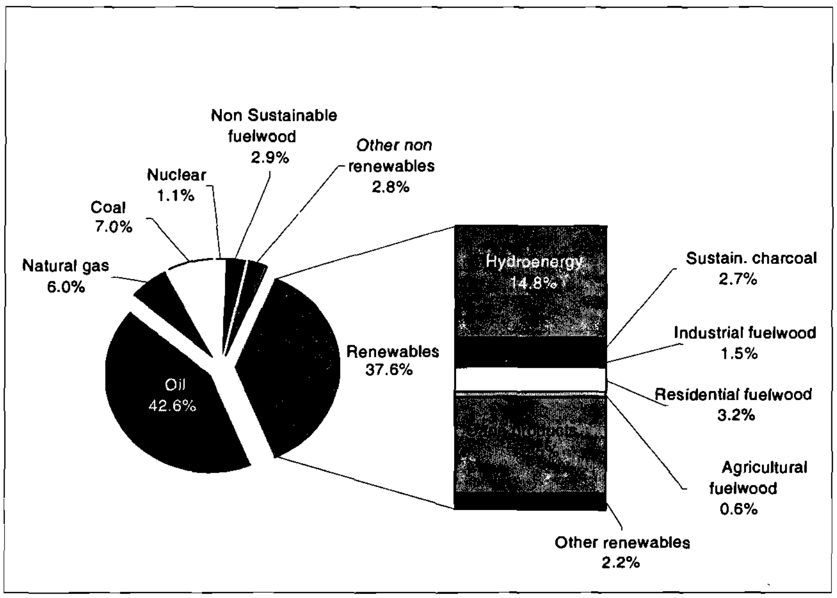
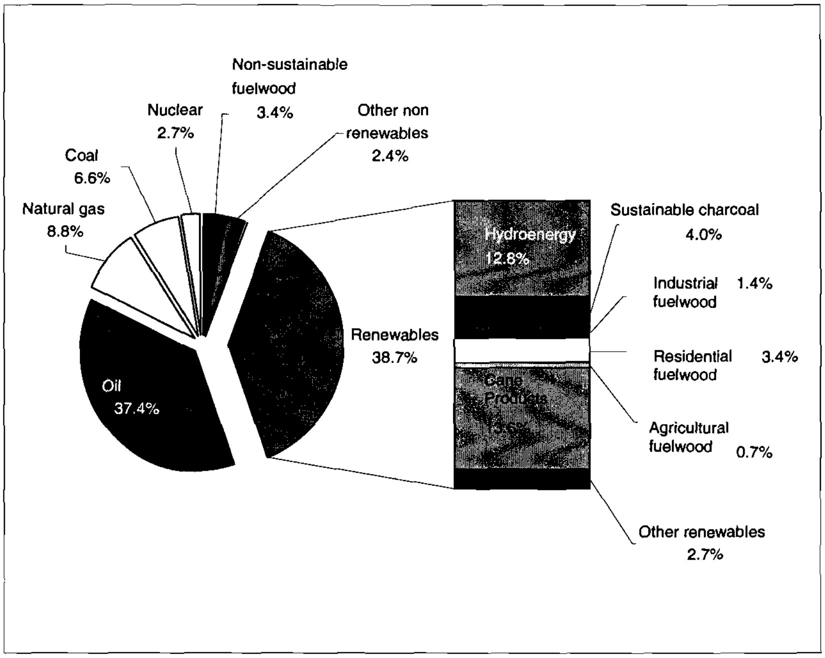


FIGURE 8 - B
BRAZIL - 2004 – ENERGY SUPPLY



Source: Author, based on data from the Energy Economic Information System (SIEE) of the Latin American Energy Organization (OLADE).

II.2 Comparative analysis of energy indices in the subregion (2002-2004)

Following the same procedure as for the document which ECLAC presented at Bonn, national performance indices for the energy sector in 2004 were calculated in relation to the role of renewable energies, comparing them with the data already available for 2002.

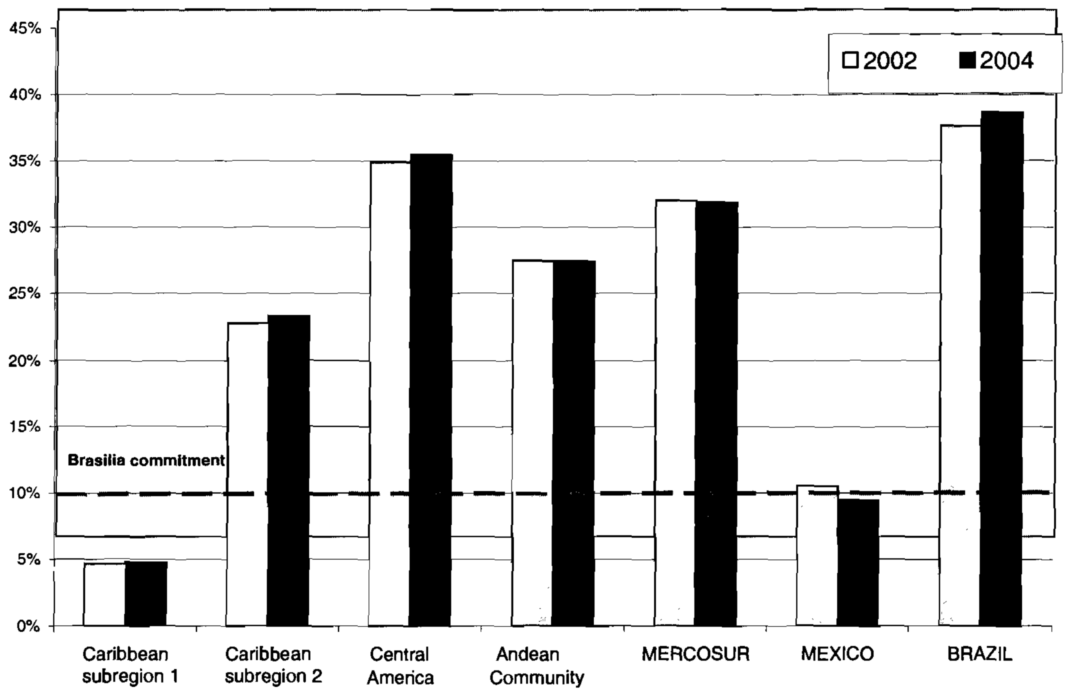
(A) Energy supply renewability index (RI)

The RI expresses the total supply of all renewable energies in relation to total energy supply.

The RI indicates the relative share of a country's renewable sources used to supply domestic energy directly for final consumption sectors and as intermediate sources used in transformation centres.

Note that the target in the Latin American and Caribbean Initiative for Sustainable Development, which emanated from the World Summit on Sustainable Development in Johannesburg and was later ratified by the Brasilia Platform, is for 10% of primary energy supply to come from renewable sources by the year 2010. A high index rate means that the country or subregion is over quota and therefore meets the target proposed in the Initiative for the countries of Latin America.

FIGURE 9
ENERGY RENEWABILITY INDEX – RI
Supply of renewables/total energy supply



Source: Author, based on data from the Energy Economic Information System (SIEE) of the Latin American Energy Organization (OLADE).

A comparison of the RI index values for the different subregions between the years 2002 and 2004 shows that:

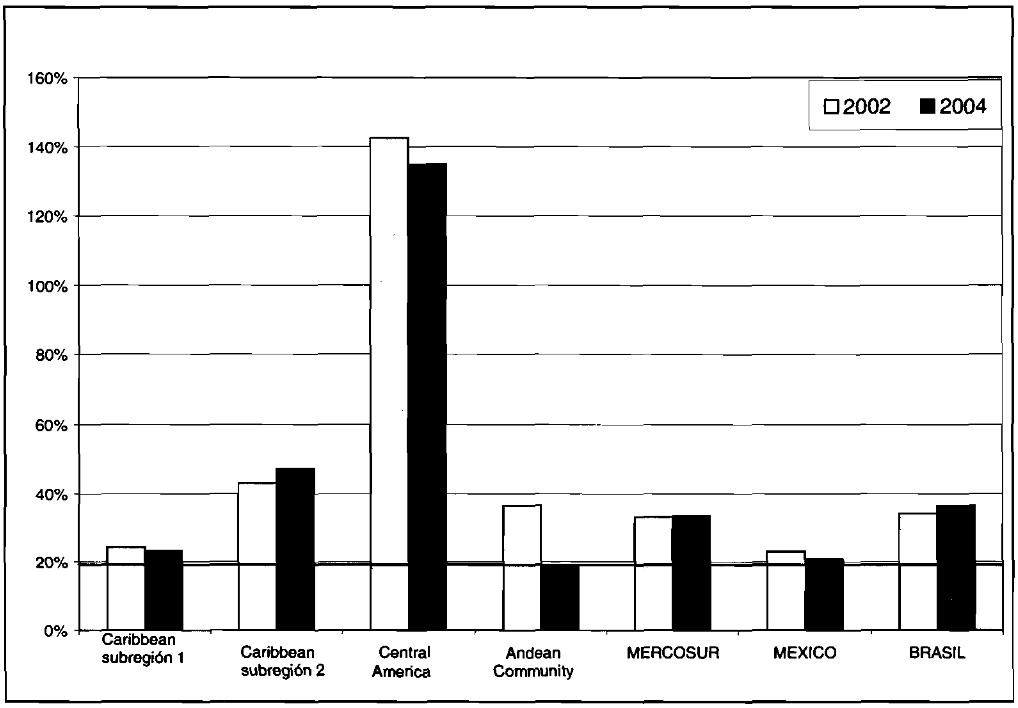
- Caribbean Subregion 1 still comes well below the 10% threshold. Whereas in 2002 Mexico exceeded the threshold by a mere half a percentage point, in 2004 its share of renewables fell below the threshold (see figure 9). This means that the countries of Caribbean Subregion 1 and Mexico need to make a major effort if they wish to meet the target of a 10% share of renewables in total energy supply.
- Those subregions which came within the 20% to 30% range in 2002 (Caribbean Subregion 2 and the Andean Community) have not substantially improved their renewable share, so they need to take decisive action, both in policy terms and by promoting renewable projects, if they wish to maintain their current share of renewables in TES at above the reference threshold.
- The only country to have shown substantial growth in its renewable portion was Brazil, which is starting to see the benefits of its efforts in terms of policies to promote alternative energies.

(B) Residential sustainability index (RSI)

The RSI expresses fuelwood consumption in relation to the consumption of oil derivatives or secondary hydrocarbons (kerosene, diesel, liquefied petroleum gas) in the residential sector. It indicates the importance of fuelwood in meeting basic energy requirements, mainly for cooking, heating and boiling water.

A high RSI means not only that the country is heavily dependent on fuelwood to satisfy the needs of its population, but also that a specific study is required to analyse the "sustainable fraction" of the fuelwood used. The RSI also reflects certain social factors, such as poverty levels in poor urban and rural areas and access to better quality energy sources, which tend to cost more but are more efficient and productive and cut the time required to gather fuel, in addition to lowering indoor pollution levels, as the following figure shows.

FIGURE 10
RESIDENTIAL SUSTAINABLE INDEX – RSI
(Fuelwood consumption/consumption of secondary hydrocarbons)



Source: Author, based on data from the Energy Economic Information System (SIEE) of the Latin American Energy Organization (OLADE).

A comparison of the RSI index values for the different subregions between 2002 and 2004 shows that:

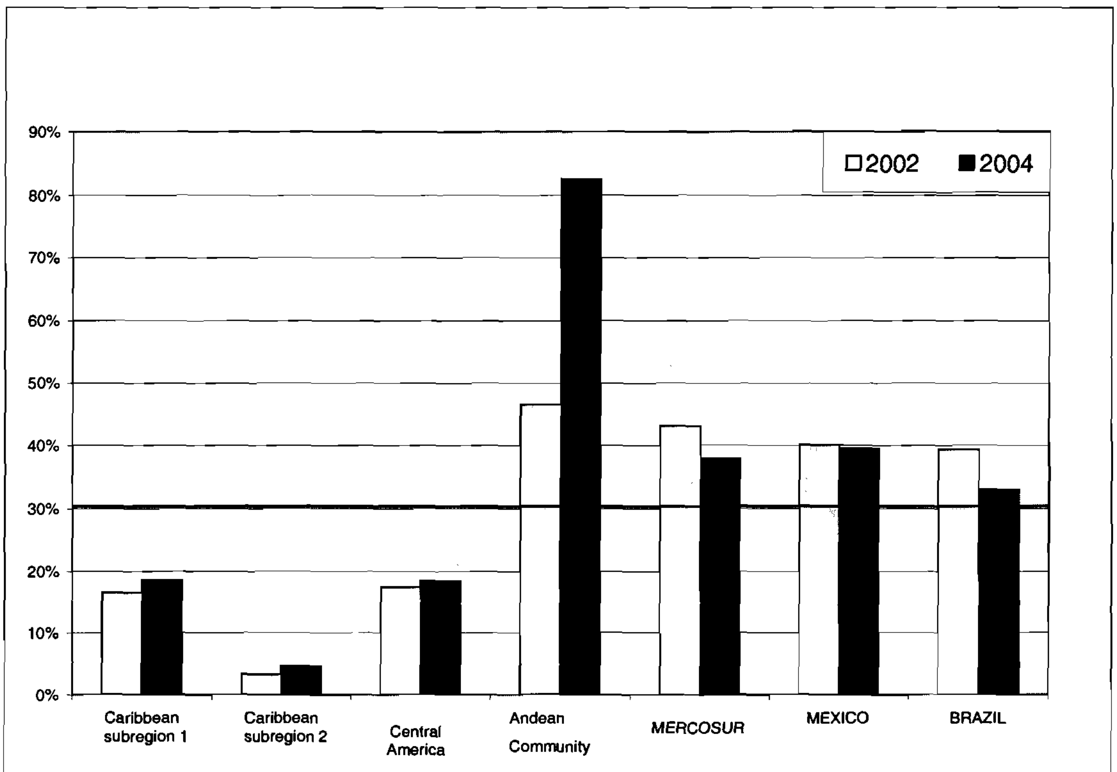
- The subregions most dependent on fossil fuels (Caribbean Subregion 1 and Mexico) still come under the 20% threshold and are heavy users of secondary hydrocarbons (see figure 10). This means that they should post a higher useful per capita energy consumption rate than the other subregions, and hence are better at satisfying basic energy needs. There was a steep reduction of almost 50% in the AndeanCommunity's index, owing to a decrease in residential fuelwood use, as explained in the previous chapter.

- Mercosur, Caribbean Subregion 2 and Brazil come within the 20% - 50% bracket, which is considered to be the "balanced" range.
- As in 2002, the Central American subregion continues to have high residential sustainability rates, which indicates over-dependence on fuelwood in both poor urban and rural areas. As a result, the basic energy needs of these areas are not being properly met in terms of access to better quality energy sources.

(C) Hydroenergy dependency over total renewable supply index (HDI)

The HDI expresses hydroenergy supply in relation to primary renewable energy supply, showing how important hydroenergy is in a country's renewable supply. Thus, a high HDI means that a country's share of renewable energy is linked more closely with meteorological factors than with technological factors.

FIGURE 11
HYDROENERGY DEPENDENCY OVER TOTAL RENEWABLE SUPPLY INDEX -HDI
(Hydroenergy supply/supply of all renewables)



Source: Author, based on data from the Energy Economic Information System (SIEE) of the Latin American Energy Organization (OLADE).

A comparison of the HDI values for the different subregions between the years 2002 and 2004 shows that the MERCOSUR countries and Mexico still have high hydroenergy dependency rates.

The significant increase in the Andean Community's HDI stems from the fact that not only does hydroenergy continue to be its sole renewable energy source, but also both cane products and fuelwood have fallen as a share of energy supply. In the case of MERCOSUR and

Mexico, the development of other sources, like geothermal and solar power, has not yet been included in the energy balance sheet.

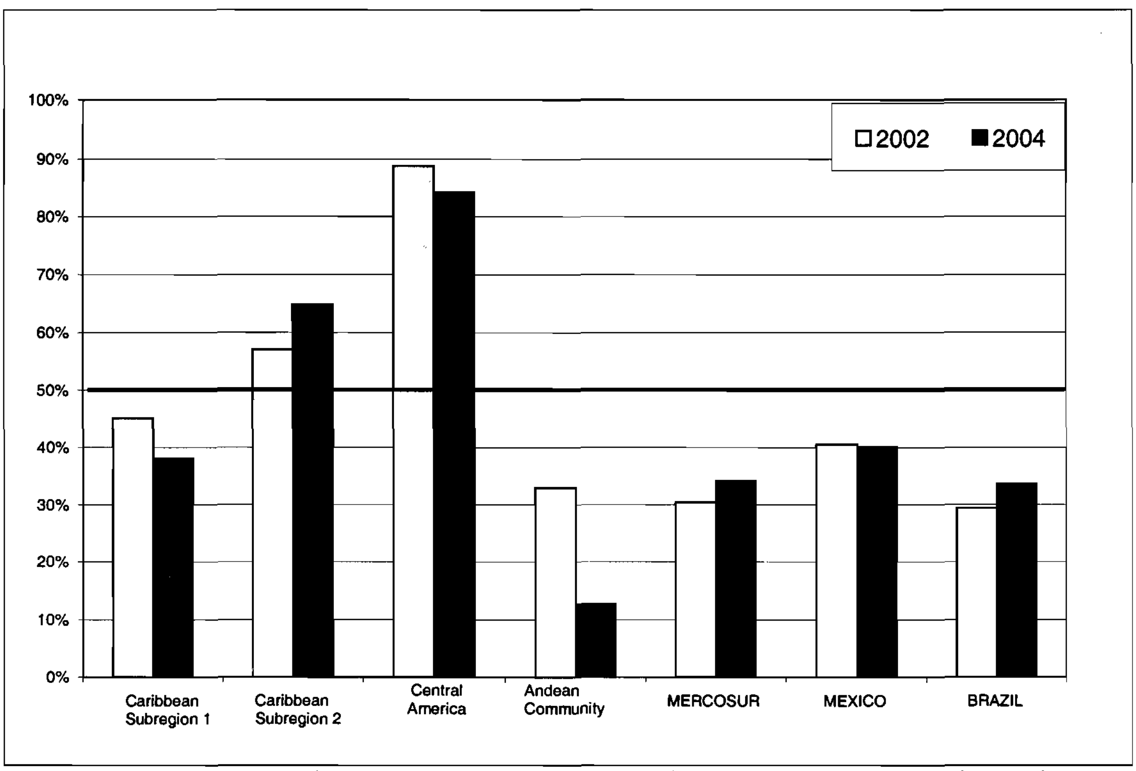
In the case of Brazil, the increasing importance of biomass (from both charcoal and cane products), as well as other alternative technologies, is starting to have a noticeable impact on the renewable portion of TES. This is reflected in a reduction in the relative share of hydroenergy within the renewable portion (i.e. a reduction in the index).

Central America and Caribbean subregions 1 and 2 continue to have very low hydroenergy dependency rates since they have no significant hydroelectric resources (see figure 11).

(D) Forest energy dependency over total renewable supply index (FDI)

The FDI expresses total fuelwood supply in relation to total renewable primary energy supply. It indicates how important wood energy is in a country's renewable supply. A high index rate means that the country's share of renewable energy is linked to an intensive, and hence not always sustainable, use of forestry resources.

FIGURE 12
FOREST ENERGY DEPENDENCY OVER THE TOTAL RENEWABLE SUPPLY -FDI
(Fuelwood supply/supply of all renewables)



Source: Author, based on data from the Energy Economic Information System (SIEE) of the Latin American Energy Organization (OLADE).

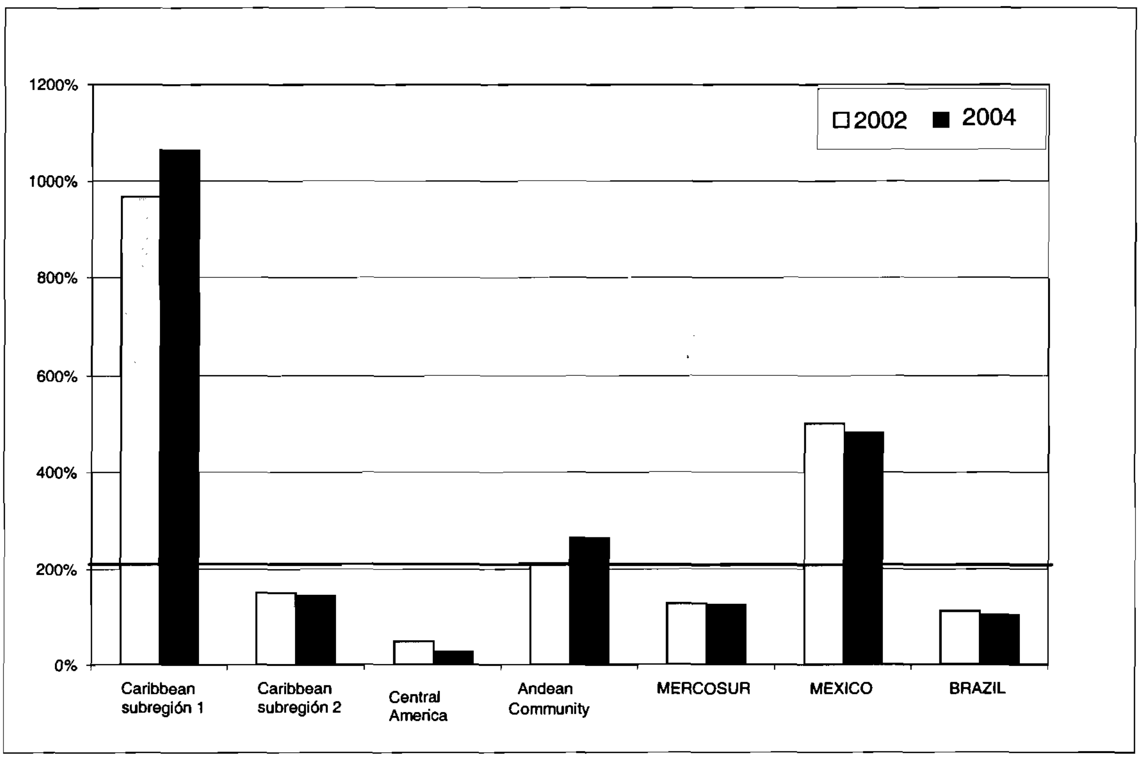
For a comprehensive and consistent analysis, the FDI should be compared (subregion by subregion) with the RSI. However, a comparison of the index values for the different subregions between the years 2002 and 2004 shows that:

- The supply of renewable energy in the Caribbean Subregion 2 countries, particularly those of Central America, continues to be closely linked with the availability of fuelwood, although there has been a noticeable drop in Central America (see figure 12).
- As already mentioned, the Andean Community's FDI rate dropped still further in 2004, since hydroenergy accounts for an increasingly high proportion of the Community's total renewable sources.

(E) Oil dominance index (ODI)

The ODI expresses the primary energy supply of oil in relation to a country's total supply of renewable energies, indicating how important a role oil plays in energy supply compared with renewable energy availability and use.

FIGURE 13
OIL DOMINANCE INDEX - ODI
(Oil supply/supply of al renewables)



Source: Author, based on data from the Energy Economic Information System (SIEE) of the Latin American Energy Organization (OLADE).

A comparison of the ODI index rate for the different subregions between the years 2002 and 2004 shows that:

- As one might expect, the subregions with the heaviest dependence on fossil fuels (Caribbean Subregion 1 and Mexico) still have index rates in excess of 400% (see figure 13), meaning that the oil supply is four times greater than the supply of renewable energies (in the case of Caribbean Subregion 1 it is more than 10 times greater). The trend in the Andean subregion is for heavier oil dependency, owing primarily to the Bolivarian Republic of Venezuela's increasingly important role as an oil supplier.
- The Central American countries, which are net hydrocarbon importers, have reduced their ODI rate even further, given that their respective energy supplies are balanced with renewable energies (based mainly on fuelwood), which increase their share (see figure 13).

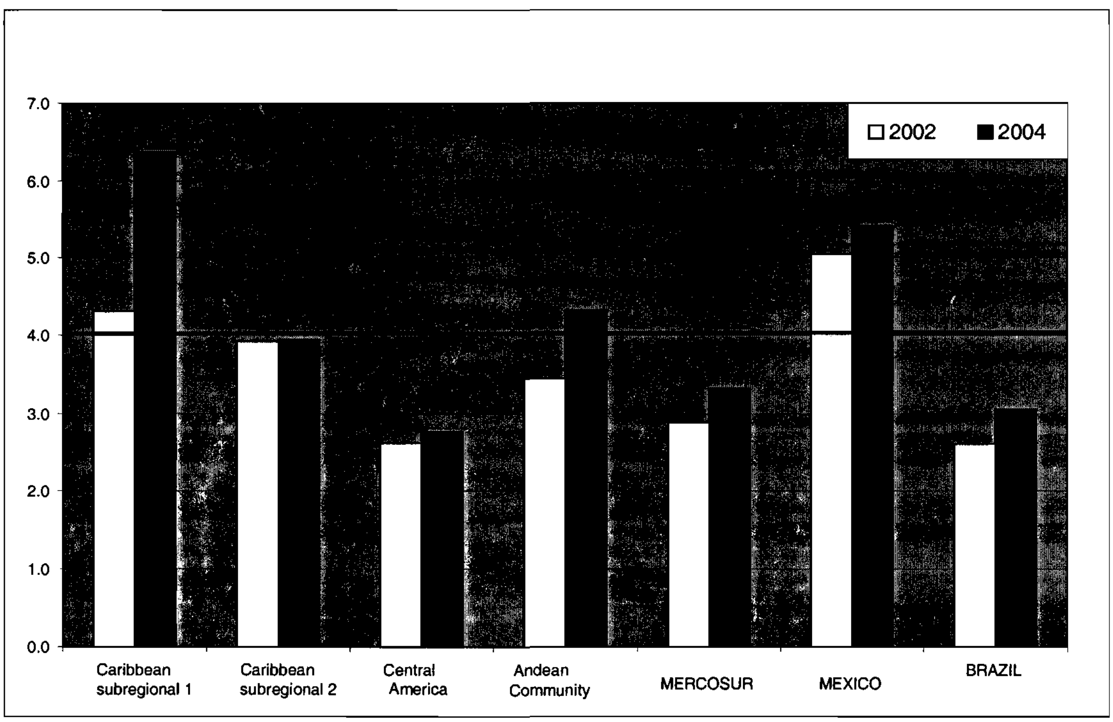
(F) Polluting consumption index (PCI)

The PCI expresses total emissions of CO_2 (in thousands of metric tons) emitted into the atmosphere in relation to a country's total final consumption in that year (in thousands of barrels of oil equivalent, or BOE). Thus, a high index rate means that a country's energy consumption (electric power generation sector + transport sector) is particularly polluting.

It is important to compare this index over a period of time (for instance, from 1980 to 2004), in order to identify long-term trends.

If a country already had a high index in 2004 and this rate has been rising continually over the past 20 years, then it is a country with a high global environmental risk, since it is emitting an excessive and disproportionate amount of greenhouse gases per unit of consumption.

FIGURE 14
POLLUTING CONSUMPTION INDEX – PCI
(Tons of CO_2/Tons Barrel of Oil Equivalent



Source: Author, based on data from the Energy Economic Information System (SIEE) of the Latin American Energy Organization (OLADE).

A comparison of the PCI values for the different subregions between the years 2002 and 2004 shows that:

- The Central American countries have a low (albeit slightly rising) PCI owing to their large share of renewables in total energy supply (see figure 14).
- Once again, the subregions with the heaviest dependency on hydrocarbons (Mexico and Caribbean Subregion 1) are those which, in comparative terms, emit very large amounts of greenhouse gases. In Caribbean Subregion 1 the increase has been dramatic (40% more than in 2002).
- There has also been a substantial rise in the PCI in MERCOSUR and the Andean Community.

In general, all the subregions have higher levels of CO_2 emissions. This probably has more to do with the exponential increase in the car fleet in most countries in the region and less to do with electricity generation factors, as an analysis of the next index confirms (see figure 15).

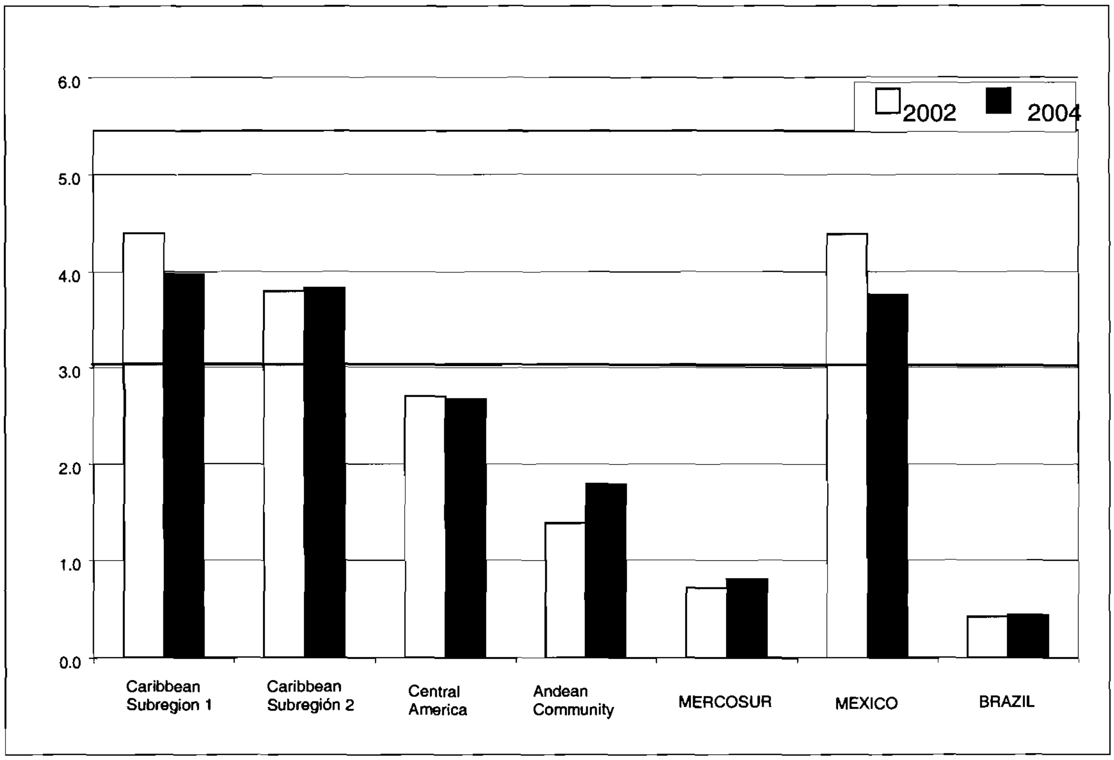
(G) Electric power generating pollution index (EPI)

The EPI is directly linked with a country's entire energy mix and, in particular, with the "hydro versus thermal" balance in the total power generation capacity used. In countries with no hydroelectric resources, clearly the EPI will be higher.

The EPI expresses the quantity of CO_2 emitted (in thousands of metric tons) in the electricity generation process (per GWh), indicating how polluting the production of each GWh of electricity is.

In qualitative terms, a high index means that, in addition to the simple technical/operating cost of generation, there is a high environmental cost to the country in producing that amount of GWh of electricity, both locally (direct and indirect pollution in the vicinity of power plants) and globally (emissions of substances that contribute to the greenhouse effect).

FIGURE 15
ELECTRIC POWER GENERATING POLLUTION INDEX – EPI
(Tons of CO_2 from electricit generation/GWh of total electricity)



Source: Author, based on data from the Energy Economic Information System (SIEE) of the Latin American Energy Organization (OLADE).

A comparison of the EPI index values for the different subregions between 2002 and 2004 shows that:

- Countries in the Andean and expanded MERCOSUR subregions are relatively "clean" in terms of electric power generating processes (see figure 15). The low EPI rate stems basically from their heavy reliance on hydroenergy, as the HDI rate shows.
- In the Andean Community, however, the EPI rate is growing markedly, probably as a result of aging generating stations, which has made them more polluting.
- Mexico and Caribbean Subregion 1 show that their generation processes continue to contribute significantly to pollution in terms of CO_2 emissions, although there has been a "virtuous" reduction in the EPI rate. This may stem from technological improvements in some plants and from the entry into operation of new natural gas power plants in countries like Jamaica.

In general the trend in the EPI rate has been in reverse proportion to the PCI rate, confirming that the increase in CO_2 emissions between 2002 and 2004 stemmed largely from a sharp rise in consumption by the region's transport sector.

Chapter III
Biofuels in Latin America and the Caribbean: status and prospects

The document which ECLAC presented to the International Conference for Renewable Energies in Bonn stated that Latin America and the Caribbean (especially Central America) are in an ideal position in the world to incorporate biofuels into their energy structure.

This has been made possible by the following factors: (i) the possibility for turning biofuel into fuel for use in transport vehicles; (ii) the current shortage of oil reserves; (iii) significant development of biotechnology; (iv) the availability of land in the countries of the region for growing energy crops and (v) the need for a new perspective on rural development. All this calls for a strategic review to open up wider and clearer opportunities for this type of renewable energy.

Accordingly, the ECLAC proposal presented at Bonn was based on the following premises, specifically focusing on Central America's potential and prospects:

- Biofuels are increasingly widely adopted renewable alternatives.
- Developments in ethanol production technology have resulted in far greater productivity levels than with other alternatives.
- In the 1980s, unsuccessful attempts were made to introduce bioethanol into Central American countries.
- Some Central American countries already meet the requirements for promoting the use of gasohol[4] in the short term.
- There has been progress with initiatives to formalize gasohol programmes in the countries of the region.

Based on the above premises, the ECLAC proposal for Central America makes a number of points:

- Bioethanol requires support mechanisms to make it viable.
- A review is required of the high level of government intervention in the sugar industry, which could affect the development of biofuels.

[4] A mixture of nine parts lead-free gasoline and one part alcohol (bioethanol).

- It is important to build the institutional capacity to recognize the potential benefits, impacts and limitations of biofuels.
- Biodiesel is still being developed and its costs are highly uncompetitive.
- Central America can improve its energy sustainability rationally by using biofuels.
- Some of the important aspects that must be taken into account in order to structure sound programmes for the rational introduction of biofuels into Central American countries include public information and a proper balance of prices and costs.

This chapter aims to follow up discussions on the Bonn document proposals, providing an overview of the biofuels sector throughout the entire Latin American and the Caribbean region. It discusses the potential and applicability of bioethanol versus biodiesel, and proposes new analytical approaches for an in-depth understanding of the problems hindering the development of biofuel production and use in the region.

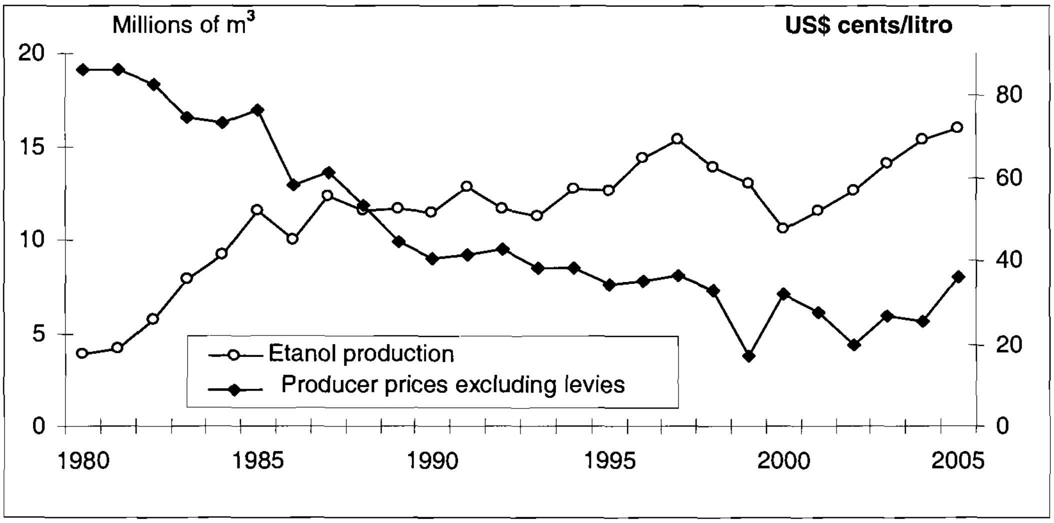
III.1 Bioethanol: experiences in Latin America and the Caribbean

Bioethanol or ethanol can be produced from sugary feedstocks like sugarcane, or from starchy feedstocks like maize and cassava, and is suitable for use in spark-ignition internal combustion engines (Otto cycle), either pure (as hydrous bioethanol) or in mixtures of anhydrous bioethanol and gasoline, otherwise known as gasohol.

In 1975, when **Brazil** was importing 77% of its fuel requirements, the Brazilian Government resuscitated bioethanol fuel in response to the oil shock, creating the National Alcohol Programme (Proálcool). It also lent strong support to investment in distilleries, guaranteeing demand by ruling a compulsory minimum bioethanol content in gasoline and setting a compensatory price for producers.

Proálcool was a government and then a State programme only up until 1990 and between 1997 and 2002 its support mechanisms were gradually withdrawn. Bioethanol fuel production is now a consolidated energy programme, which has progressed beyond the tax subsidy phase and is now being steadily developed and expanded in the current price and cost scenario. At present, the sugar/alcohol sector receives revenues of US$ 8.3 billion per year (1.6% of Brazil's GDP), creating 3.6 million direct jobs. Figures for the latest sugarcane harvest show that 5.4 million hectares were planted with sugarcane in Brazil, yielding more than 300 million tons for processing in more than 300 sugar mills, which use half the available sugar to produce fuel and have an installed capacity of nearly 18 billion litres per year. The following figure shows the trend in production and producer prices (Sao Paulo Sugarcane Agroindustry Union (UNICA), 2006).

FIGURE 16
TREND IN BIOETHANOL PRODUCTION AND PRICES IN BRAZIL



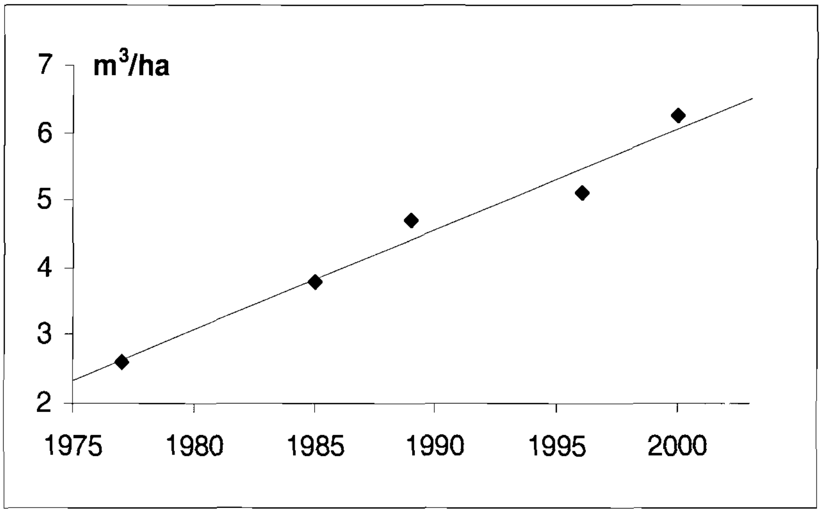
Source: based on data from the Sao Paulo Sugarcane Agroindustry Union (UNICA), 2006.

Brazil's current production of bioethanol, equivalent to approximately 200,000 barrels of oil per day, is mainly for consumption in Brazil, where it represents 40% of the gasoline market. Brazil's entire light vehicle fleet uses bioethanol, such as gasohol in 18 million cars or pure bioethanol in 3.5 million cars modified to run on this biofuel, or even modern "flexfuel" technology launched in 2003, which enables vehicle owners to fill their tanks using any proportion of hydrous bioethanol or gasohol (ANFAVEA, 2006).

In the past two years, expansion in the domestic bioethanol market, owing to the success of flexfuel engines as from 2003, coupled with attractive foreign market conditions, have revived productive investment and around 40 new sugar mills are currently being built or expanded. Under normal conditions, the cost of producing bioethanol in Brazil is estimated to be approximately US$ 0.20 per litre, of which 60% is for feedstock. As regards agro-industrial investments, the oil parity price above which it is profitable to produce bioethanol is between US$ 30 and 35 barrel, based on a cost of around US$ 60 million for a sugar mill with the capacity to process 1 million tons of sugarcane for a sugarcane harvest lasting 180 working days, producing around 450,000 litres of bioethanol per day.

A key element in the marked cost reductions observed in Brazilian sugar mills was an increase in agro-industrial productivity, stemming chiefly from higher agricultural productivity. The figure below shows the trend in bioethanol production per hectare in Brazil, showing that over the past 30 years, bioethanol production per hectare of sugarcane grew by an annual 3.7% (Brazil's Centre for Management and Strategic Studies (CGEE), 2005).

Figure 17
AGRO-INDUSTRIAL PRODUCTIVITY OF SUGARCANE-DERIVED BIOETHANOL IN BRAZIL



Source: Brazil's Centre for Management and Strategic Studies (CGEE), 2005

As one of the objectives set in 1975 for intensifying the use of bioethanol fuel in Brazil was to reduce dependency on imported oil, it is worth looking at the results three decades later.

During the period from 1975 to 2005, a total of 275 million cubic metres of bioethanol fuel were produced, equivalent to 1,510 million barrels of oil, more than 11% of Brazil's current proven hydrocarbon reserves. Valuing bioethanol fuel production at the world market price for gasoline, foreign exchange savings during the period were US$ 69.1 billion, excluding interest and Brazil's cost of debt (Nastari, 2005).

Even though the technology used in Brazil's sugar mills to produce bioethanol from sugarcane has been improved in recent decades, it is what can be considered conventional, with prospects for major improvements in the coming years and for increases in the average output through technology transfer and better processes (CGEE, 2005). In the longer-term, say the next 10 years, it is hoped to make the conversion of lignocellulosic sugarcane waste (bagasse and crop residues) into bioethanol commercially feasible, which could be a real revolution in terms of productivity and cost-effectiveness.

In **Colombia,** bioethanol production and use began when Law No. 693 was promulgated in 2001. The grounds for this law state that the main objectives are to reduce hydrocarbon and carbon monoxide emissions, to maintain and create agricultural jobs, to develop agro-industrial and to contribute to the strategic aim of energy self-sufficiency. Article one of the law states that: "all types of gasoline used in urban centres with more than 500,000 inhabitants must contain oxygenates such as alcohol fuels by September 2006 at the latest". Oxygenated gasoline is defined as gasoline containing 10% biofuel (the Ministry of Energy's Mining and Energy Planning Unit (UPME), 2006).

The Ministry of Mining and Energy and the Ministry of Environment, Housing and Regional Development were entrusted with developing subsidiary regulations. The most substantive rules were Resolution 0447 of 2003 regulating the environmental quality criteria for liquid and solid fuels for use in furnaces and boilers and in internal combustion engines; Resolution 180687 of 2003 issuing the technical regulations provided for in Law No. 693 on the production, storage, distribution and facilities for mixing alcohol fuels and their use in domestic and imported fuels; and Resolution No. 181088 of 2005 setting the price of alcohol and establishing a purchase guarantee from wholesale distributors for alcohol fuel producers. In terms of legal support for producers, Law No. 693 eliminates the departmental monopoly over the production of industrial bioethanol (article 2) and states that bioethanol use will be given special treatment in sectoral energy self-sufficiency, agricultural production and job creation policies (article 3). In addition, the law exempts bioethanol fuel for mixing with gasoline from VAT and flat-rate tax.

Bioethanol use was implemented ahead of the deadline set in the law and, after being introduced into Colombia's south-western and coffee (Eje Cafetero) regions in November 2005, the mixture went on to be used in the city of Bogotá and in central Colombia in February 2006, with the aim of gradually extending it to the whole of Colombia. In late 2005, a total of 54 cubic metres (m^3) of alcohol were consumed per day, with a target of 719 m^3 of alcohol per day by the end of the following year, corresponding to an annual 262,000 m^3 of bioethanol or 6% of Colombia's gasoline consumption. The current production capacity is around 1,100 m^3 per day, with more than 730 m^3 per day from four plants (see table 3) (UPME, 2006). According to other authors, nine projects are under study or being implemented, totalling 2,100 m^3 per day (Kafarov et al, 2006).

Bioethanol use in Colombia was carefully prepared in advance by means of information campaigns in the written press and on radio and television, coupled with seminars and courses for all those involved, including: service station personnel, car repair shop advisers and employees, employees of car dealers and traders, taxi and public transport drivers, private vehicle owners and vehicle inspection bodies. The aim of this entire information campaign was to increase confidence and knowledge among users of the bioethanol/gasoline mixture. The results of tests conducted in Colombia indicated a reduction in CO_2 emissions of between 22% and 50% in vehicles with Otto cycle combustion engines and lesser reductions in vehicles with injection engines, a reduction in hydrocarbon emissions of between 20% and 24% and an average 15% improvement in engine power owing to a higher octane index (UPME, 2006). On the specific point of fuel consumption, field trials in Colombia confirmed the positive impact of adopting gasohol containing 10% bioethanol on engine power and, to a lesser extent, on consumption (Ximena, 2004), as the following tables show.

TABLE 3
BIOETHANOL PRODUCTION CAPACITY INSTALLED AND BEING INSTALLED IN COLOMBIA

Production plant	*Feedstock*	*Capacity (cubic metres/day)*	*Entry into operation*
In operation			
Incauca sugar mill	Sugarcane	300	October 2005
Providencia sugar mill	Sugarcane	250	October 2005
Manuelita sugar mill	Sugarcane	300	March 2006
Mayagüez sugar mill	Sugarcane	150	February 2006
Risaralda sugar mill	Sugarcane	100	February 2006
Under construction			
Petrotesting S.A.	Cassava	30	December 2006
Alcohol S.A.	Sugarcane	300-100	2008 (first six months)
Maquilagro	Beet	300	2008 (first six months)
Sicarare sugar mill	Cassava	100	2008 (first six months)

Source: Kafarov et al, 2004.

TABLE 4
IMPACT OF USING GASOHOL (10% BIOETHANOL) COMPARED WITH PURE GASOLINE

Manufacturer	*Model*	*Power*	*Consumption*
Fiat	Allegro 1.3i	+9.60%	+4.40%
Fiat	Allegro 1.6i	+12.30%	+0.90%
General Motors	Corsa 1.4i	+15.90%	+6.70%
Mazda	626 L (with carburettor)	+15.40%	+3.30%
Mazda	626 GLX 2.0i	+4.50%	-1.80%
Mazda	323NE 1.3i	+3.70%	- 4.2%
Suzuki	Gran Vitara	-1.80%	+3.20%
Suzuki	Alto 1.0i	+1.50%	-2.70%

Source: Ximena, 2004.

Table 5 shows prospects for bioethanol production and use in Colombia, with an expected initial export surplus of almost half the production volume, followed by a gradual increase in domestic consumption (Brazil's Ministry of Agriculture and Rural Development (MADR), 2006).

TABLE 5
PROSPECTS FOR BIOETHANOL IN COLOMBIA

Indicator	*2010*	*2015*	*2020*
Production (cubic metres/year)	1,684	1,985	2,068
Exported fraction	48%	19%	14%
Crop-growing area (thousands of hectares)	186	204	210

Source: Brazil's Ministry of Agriculture and Rural Development (MADR), 2006.

The crop-growing area shown in the above table appears to refer solely to crops for bioethanol production. Another study estimates that for present bioethanol demand levels, a further 103,000 hectares would need to be added to the current 406,000 hectares of crops.

The same study describes how bioethanol production could affect Colombia's sugar production and exports (as shown in table 6) for different biofuel introduction scenarios (Kafarov et al, 2006).

TABLE 6
IMPACT OF BIOETHANOL ON COLOMBIA'S SUGAR INDUSTRY

Data	*2005/2006*	*Projection / 2006*
Number of projects	5	9
Production (litres/day)	1,025,000	1,600,000
	Sugar substitution (%)	
Production	23%	34%
Exports	49%	75%
	Estimated demand (litres/day)	
10% oxygenation (86% coverage)	1,013,433	1,277,533
15% oxygenation (70% coverage)		1,916,300
20% oxygenation (52% coverage)		2,555,067

Source: Kafarov et al, 2006.

In 1981, the **Costa Rican** Government produced the document Basic Guidelines for a National Alcohol Fuel Programme, laying down measures that led to the use of more than 2,000 m^3 of gasoline with a 20% bioethanol content in the same year, a volume which had risen to 13,800 m^3 by the following year. The objectives were to reduce energy dependency and to diversify the domestic sugar processing industry, adding value to molasses used as a feedstock, as well as addressing environmental issues. However, problems of product distribution and quality ground the programme to a halt in 2003, virtually eliminating use of the mixture.

Even though this bioethanol initiative made no headway in the ensuing years, production was continued to serve foreign market requirements for Costa Rican feedstocks and to make semi-processed goods for export to Brazil, Guatemala, France, Nicaragua and the United Kingdom. The principal purchasers of Costa Rican bioethanol are the United States and the Netherlands. For the 2003-2004 sugarcane harvest, Costa Rica's alcohol industry imported more than 11,800 m^3 of bioethanol, while exporting 18,900 m^3 in the same year. Taking into account the latest ten sugarcane harvests, the maximum export volume was 63,700 m^3 in 2000 (LAICA, 2005).

These operations are carried out in the facilities of the Punta Morales port terminal, which is operated by the League of Sugarcane Growers and Processors (LAICA), which is responsible for importing bioethanol and exporting sugar, molasses and bioethanol. The wharf in this terminal can take ships of up to 30,000 metric tons, 109 metres in length and 25 metres in width. The eight existing bioethanol tanks can store more than 30 million litres of bioethanol and the port has a bioethanol dehydration plant with the capacity to process 380,000 litres of fuel per day. At present, Costa Rica's bioethanol production capacity is 350,000 litres per day: the CATSA refinery produces 240,000 litres per day and the Taboga refinery produces 120,000 litres per day, not including the dehydration plant at the Punta Morales terminal (Clean Production Project in Costa Rica, 2005).

In May 2003, the Costa Rican Government issued Decree No. 31087-MAG-MINAE creating a Technical Working Committee (Comisión Técnica de Trabajo) to: "formulate, identify and design strategies for the development of domestically-distilled anhydrous bioethanol using local feedstocks as a substitute for MTBE[5] in gasoline". The basic objectives of the decree were to develop agro-industrial by reviving the economy, creating added value, improving the environment and substituting MTBE[6]. From the energy standpoint, the objectives were to diversify energy sources and to reduce dependency on imported fuels.

The Committee secured the involvement of a number of institutions: Ministry of Agriculture and Livestock (MAG), Ministry of Environment and Energy (MINAE), the state oil company RECOPE, the League of Sugarcane Growers and Processors, and others. The key objective was to define the conditions for bioethanol use in Costa Rica. Initially the aim was to introduce bioethanol/gasoline mixtures as from January 2005. However, the application of this measure was halted by an unconstitutionality appeal lodged against article 7 of the decree ordering the programme's implementation. In spite of this legal action, the Ministry of Environment and Energy and the other departments in the Committee are authorized to continue implementing projects aimed at improving knowledge of logistics and product handling.

In view of the problems encountered in the 1980s, the state oil company RECOPE carefully designed and implemented the pilot projects in four gradual phases. In the first phase a pilot test was conducted on 28 vehicles, using a mixture of gasoline and 10% bioethanol (gasoline E-10), in which:

- A better performance was observed using gasoline E-10 than using current regular gasoline.
- At no point during the period did the vehicles require corrective maintenance, that is to say, no mechanical damage occurred to the engines.

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5 MTBE *methyl tert-butyl ethe* is one of the substitutes for lead in gasoline.

6 On 20 March 2000, the United States Environmental Protection Agency (EPA) announced forceful measures to eliminate the MTBE additive in lead-free gasoline in the United States, since it has been proven to jeopardize the environment.

- The results of the hydrocarbon emissions (unburned fuels) and carbon monoxide emissions did not exceed established national thresholds and were similar to the results obtained with current regular-grade gasoline (RECOPE, 2005).

The second phase consisted of marketing gasoline containing 7.5% bioethanol at 64 service stations in the Guanacaste and Pacífico Central areas, supplied by the RECOPE plant in Barranca. The service stations serve a fleet of approximately 50,000 vehicles, which represents around 12.5% of Costa Rica's gasoline consumption. Prior to actually marketing the mixture, training was provided to the personnel responsible for bioethanol handling and quality control in terminals, the base gasoline was properly formulated to ensure it continued to comply with environmental requirements, service station tanks were inspected and all the people directly concerned were informed about using gasohol.

Phase two has been under way since February 2006, with positive results. No major changes in fuel consumption have been observed in the area and only a few complaints have been received from consumers, usually stemming from other factors or from poor engine maintenance. To date RECOPE has received no complaints from service stations and there have been no problems with handling the fuel (RECOPE, 2006). The first batch of bioethanol used was imported by RECOPE under an international tender, since domestic production is earmarked for export to the United States. Before long Costa Rica's bioethanol production is expected to grow to serve the domestic market as well.

The next phases involve analysing results and possibly introducing bioethanol use nationwide, which would involve: (i) equipping all RECOPE plants with the required infrastructure to store, mix and distribute bioethanol (for which an estimated investment of US$ 3 million will be needed); (ii) defining the necessary policy and legal framework, including regulations for the inspection of service stations; and (iii) defining aspects of the relative share of agricultural and energy sectors.

While not as far advanced as the above-mentioned countries, other countries in the region are also introducing bioethanol use or conducting studies to lay the foundations for future bioethanol programmes, with varying degrees of progress. The aim of this study is not to make an exhaustive review of this fast-evolving issue, where new initiatives are springing up every day, but to point out that, in a number of ways, bioethanol is coming to be seen as just another fuel in the energy structure of many countries in the region.

In **Argentina**, the National Biofuels Programme, approved by Law No. 26093 of 2005 establishing a Plan to promote the Production and Sustainable Use of Biofuels for a 15-year period, including various tax incentives and the creation of a research-promotion institution, lays down quality standards and criteria for project approval and administering any subsidies. Although the programme emphasizes Argentina's comparative advantages in vegetable oil production and focuses more on biodiesel, it also envisages promoting the use of bioethanol, which must be mixed with gasoline in the proportion of "at least" 5%. The demand for gasoline in the year 2010 is calculated to be 4 million m^3, which means that 200,000 m^3 of bioethanol will need to be produced in around six agro-industrial plants, for a total investment of US$ 120 million. Consequently, maize was adopted as the feedstock, 550,000 tons of which will be needed to meet predicted demand for 2010: 2.8% of current production, cultivated on 106,000 hectares, which is 3.2% of the current maize-growing area (Argentina's Secretariat of Agriculture, Livestock, Fisheries and Food (SAGPA), 2006).

Another study, also on the production of bioethanol from maize, estimates that five agro-industrial plants, each with an annual capacity to produce 40,000 m^3 of bioethanol, for a total investment of US$ 90 million, could supply the market with sufficient bioethanol for a 5% mixture in gasoline. The study estimates a production cost of US$ 0.301 per litre of bioethanol, assuming a maize price of US$ 53 per ton and a price for corn distillers' dried grains (DDG), a by-product used for animal feed, of US$ 89 per ton (Fraguío, 2005).

In **Bolivia**, particularly in the Department of Santa Cruz, the sugarcane processing industry has been conducting bioethanol production projects targeted at the overseas market, in the wake of excellent results from the Guabira sugar mill, which in the latest sugarcane harvests has been exporting around 50,000 m^3 of bioethanol fuel per year to the Italian market using a variety of logistical options. As regards the domestic market, studies conducted in 2005 recommended that a law be formulated to promote the new fuels, estimating that the addition of 25% biofuel to gasoline would create demand for 90,000 m^3 of bioethanol, which would expand the sugarcane-growing area by more than 30,000 hectares (Boliviahoy, 2005).

In **Chile**, the state oil company (ENAP) and the Iansa Group, which markets agricultural products, have carried out studies into the feasibility of producing bioethanol from cereals and beet (Ramírez, 2006). The idea is to table legislation that makes it compulsory to mix 10% biofuel into gasoline, even though ENAP appears to prefer the use of gasoline mixed with ETBE,[7] since it is easier to transport and has lower steam pressure (ENAP, 2006).

In **Cuba**, a country with a long-standing sugarcane-growing tradition, there is obvious potential for producing bioethanol for energy. Efforts to include bioethanol date back many years. For instance, mixtures of bioethanol with gasoline (called "*mofuco*") were used during the Second World War in response to a shortage of oil-derived fuels. Bioethanol was also used as a fuel on a number of other occasions, but the practice never became widespread. However, many experiments followed. For instance, in the 1970s the Centre for the Development of the Oil Industry and the Cuban Oil Institute carried out research into various types of base gasoline and a number of blend alternatives, ranging from 15% to 30% bioethanol. The results show that mixtures increase the octane content and reduce toxic gas emissions and environmental pollution.

The latest experiment was conducted at the Centre for Transport Research and Development (CETRA) in 1997, during which 114 vehicles travelled a total of 1.5 million kilometres using mixtures of regular gasoline with bioethanol. The research concluded that, under Cuba's conditions, between 20% and 25% bioethanol could be added to regular gasoline to achieve a stable and effective mixture (Salomón, R., 2006). A number of studies have been conducted into bioethanol production alternatives and the energy implications for this Caribbean island (Almazán and González, 1999).

Even though **Ecuador** is a major hydrocarbon producer, it loses a substantial volume of foreign exchange by importing oil derivatives, totalling US$ 4,611,000 during the period from 1998 to 2005. For this reason, and also to seek to reduce emissions and to promote agro-industrial development, the Ecuadorian Government proposed a Programme for Formulating Premium-Grade Gasoline using Anhydrous Bioethanol.

The programme sets out to introduce biofuel into Ecuador's energy structure in two phases, starting with a pilot plan in the city of Guayaquil, after which it will be extended to the entire country. In phase one, the estimated demand is for 800,000 litres per day of premium-grade gasoline, which would require 40,000 litres of bioethanol for a 5% bioethanol mix. The aim is to begin with a 5% mix and to gradually increase the bioethanol content to 10%, which would increase nationwide demand for bioethanol to approximately 590,000 litres per day, or approximately 215,000 m3 per year (Ecuador's Ministry of Energy and Mines (MEM), 2005). To this end, Executive Decree 2332 was promulgated in late 2004, article one of which states that "the production, marketing and use of biofuels is in the national interest". The same decree

[7] Ethyl tertiary butyl ether (ETBE) is an ether derived from ordinary fuels like butane and bioethanol and has similar characteristics to MTBE.

created the Consultative Committee on Biofuels of the Presidency of the Republic, a body that will develop and define the general guidelines, as well as the adoption of the measures required for the production, handling, processing and marketing of biofuels. The selected feedstock was sugarcane.

Since 2003, the Governments of El Salvador and Guatemala have been discussing laws for promoting the use of bioethanol, but up to now problems to do with price setting have prevented optimum use of this biofuel locally (ECLAC, 2004a). However, both countries continue to develop important agro-industrial projects for the production of bioethanol for the United States market. In Guatemala, bioethanol has been produced and exported for more than 20 years and a new distillery has been attached to the Palo Gordo sugar mill south of Guatemala City. In addition, a new technologically advanced bioethanol distillery (Distilería Bioetanol) was created in 2005 to increase bioethanol supply to the United States market (ECLAC, 2006).

There have been various investments in **El Salvador** in the past two years for producing bioethanol from imported pre-processed products or from domestic feedstock. In late 2005, the multinational Cargill put a dehydration distillery into operation and, more recently, American Renewable Fuel Suppliers, a joint venture of firms from Brazil, El Salvador and the United States, inaugurated its distillery in Acajutla (Sonsonete), with a daily production capacity of 700 m^3 of anhydrous bioethanol. The distillery processes imported hydrous bioethanol from China and sells it to a group of Hawaian oil companies. It expects to dispatch 15 million litres of anhydrous bioethanol for energy use (Góes, 2006). The clear potential of these countries as bioethanol producers would indicate that they themselves will soon incorporate biofuels into their energy structures.

In November 2005, the Government of **Jamaica** set itself the challenge of building a national bioethanol fuel industry, commissioning the state-owned refinery Petrojam, jointly with the Brazilian company Coimex, to build a bioethanol plant with a production capacity of 182 million litres. In fact, Jamaica has set itself the target of completely substituting bioethanol for methyl tert-butyl (MTBE) as a fuel additive by the year 2008, as MTBE currently comprises 10% of the country's gasoline consumption. In August 2006, the company Jamaica Broilers Group announced a 1.1 billion Jamaican dollar plan to build a new dehydration plant at Port Esquivel to make bioethanol from sugarcane. The plant will produce 240 million litres of bioethanol and is expected to begin operations in May 2007. The sugar mill will most probably use Brazilian technology, taking advantage of the Brazilian Government's soft loan to Jamaica (US$ 100 million) to facilitate imports of Brazilian machinery and equipment for Jamaican sugarcane cultivation.

Guyana aims to diversify its sugarcane processing industry to include bioethanol manufacturing. Studies by the state sugar refinery, Guaysuco, indicate that by modernizing two sugar mills it would be possible to produce 11 million litres of biofuel at a competitive cost, which would be enough for a 10% mixture in all the gasoline consumed in Guyana (Davis, Stuart and Bhim, 2005). Guyana also plans to introduce innovative technology to use potatoes as a bioethanol feedstock.

In **Paraguay**, bioethanol has been used regularly for many years as a pure fuel or in mixtures with gasoline, and the specifications for anhydrous and hydrous bioethanol are defined in Paraguayan Standard PNA 025 of 1980. The Ministry of Industry and Commerce is responsible for adjusting the biofuel content in line with available supplies and relative prices. For instance, Resolution 153 of March 1999 established a 17% bioethanol content in all types of gasoline, which Resolution 119 reduced to 6% in March 2001 and Resolution 248 increased once more in May 2006, defining a 24% bioethanol content in regular-grade gasoline and an 18% content in premium-grade gasoline (Ministry of Industry and Commerce (MIC), 2006a).

In order to reduce gasoline prices, the Paraguayan Government authorized the distribution of "economical gasoline" with a minimum 18% biofuel content as from 2004. At present the Troche Distillery produces an annual 5 million litres of bioethanol for mixing with gasoline. According to official statistics, in addition to anhydrous bioethanol mixed with gasoline, there is a limited consumption of hydrous bioethanol of around 651,000 litres in 2004 and 211,000 litres in 2005 (MIC, 2006b), although the trend is now rising owing to the proliferation of flex-fuel vehicles (Motor, 2006).

The Ministry of Industry and Commerce action plan includes the "Sustainable Mixture" programme which aims to expand the current production capacity of anhydrous bioethanol by associating the Government with four distilleries to "consolidate the marketing of gasohols containing primarily domestically-produced bioethanol, in a sustained and sustainable manner". The target set is for the bioethanol in the mixture to rise to 20% by 2007 and stabilize thereafter, meaning that it will not be dependent on the sugarcane harvesting period (MIC, 2006c). To achieve this aim, an estimated 45,100 m^3 of bioethanol would be needed, requiring a sugarcane-growing area of 8,631 hectares. Law No. 2748 on the Promotion of Biofuels was approved in 2005 and provides an important framework which, associated with existing quality regulations and standards, sets out the conditions for implementing the 2006-2008 Biofuel Production Programme, with support for producers and with energy, social and environmental objectives.

In 2003, **Peru**'s Law No. 28054 on Promoting the Biofuels Market was promulgated in order to establish the general framework for promoting biofuel development. According to the principles of this law, the biofuels market should be based on free trade and free access to economic activity. The law aims to diversify the fuel market, promote agricultural and agro-industrial development, reduce environmental pollution and offer an alternative market in order to combat drugs.

Supreme Decree No. 013-2005-EM of 2005 approved the Implementing Regulations for the law, establishing that all types of gasoline should contain a mix of 7.8% alcohol fuel. The regulations also stipulated that the mixtures must be produced in authorized supply plants and establishes a timetable for the application of both alcohol fuel in gasoline and the application of biodiesel nationwide. Biofuels have not yet begun to be marketed on a commercial scale (the projects currently being implemented are pilot projects), mainly for lack of technical standards on biofuels. To get around this problem, the Government has set up a committee responsible for drafting Peruvian technical standards for biofuels.

The **Dominican Republic** had plans to use bioethanol for energy decades ago. In fact, Law No. 2071 on Bioethanol was created in 1949, albeit without much success. Subsequent energy laws, such as the Law on Hydrocarbons and Electricity, also aimed to create a number of incentives for developing renewable energy sources, but they were not enough. Lastly, Decree 732-02 was issued in 2002 to foster the production and use of bioethanol fuel. Under current conditions, an annual 1,178,000 m^3 of gasoline is consumed and 61,000 m^3 of bioethanol would be required for a mixture containing 5% bioethanol, which in turn would necessitate around 20,000 hectares of sugarcane (CNE, 2006), as the following table shows.

TABLE 7
PROJECTED DEMAND FOR BIOETHANOL IN THE DOMINICAN REPUBLIC

Year	*Gasoline consumption (thousands of cubic metres)*	*Bioethanol in the mixture (percentage)*	*Bioethanol consumption (thousands of cubic metres)*
2006	1 226	5	61
2007	1 178	12	141
2008	1 178	16	189
2009	1 178	19	224
2010	1 178	22	259

Source: CNE, 2006.

The Dominican Republic's sugarcane crops currently occupy around 350,000 hectares and an estimated 200,000 hectares could be added for growing biofuel feedstocks without competing with agricultural land destined for food production or with forest reserves. That is to say, in principle there are plenty of possibilities for producing local feedstocks for a large proportion of the country's fuel consumption. The above table shows the future trend in bioethanol content, which could rise to 22% by 2010, directly impacting on bioethanol requirements and on gasoline imports (CNE, 2006).

Uruguay aims to establish a legal framework for gradually introducing biofuels into the country's energy structure. It is planned to achieve a 5% bioethanol content in gasoline by the year 2015, requiring mainly sugarcane to be used as the feedstock (Triunfo and Larrosa, 2006).

In late 2005, the President of the **Bolivarian Republic of Venezuela** announced that he would earmark more than US$ 900 million for bioethanol production over the following five years, using bioethanol as a substitute for polluting gasoline additives and targeting a daily production of 4,000 m3 by 2010 (América Economía, 2006). According to other sources, Venezuela's state oil company PDVSA will build 15 sugarcane distilleries for producing bioethanol, in the expectation of creating more than 1 million direct and indirect jobs. The bioethanol projects in the State of Guárico, where 17,000 hectares of sugarcane will need to be grown, are more advanced (ABN, 2006). In August 2005, the state oil company had already begun to mix bioethanol imported from Brazil with gasoline distributed in eastern Venezuela. Around 20,000 m3 of bioethanol per month is imported via the Puerto La Cruz port terminal, after which it is transported to the San Tomé, Maturin, Puerto Ordaz and Ciudad Bolivar terminals along 590 km of multi-purpose pipelines (PDVSA/Petrobras, 2005).

As described above, bioethanol is already a reality in a number of Latin American countries and, while objectives, production structures and scales differ, all these bioethanol projects basically use sugarcane or molasses as feedstocks and there are prospects for growth in all the countries studied.

To make a very preliminary comparative assessment of the **bioethanol production potential of countries in the region** (in terms of land availability and size of the sugar industry), data on total agricultural area, area planted with sugarcane, sugar production (FAOSTAT, 2006) and demand for gasoline (figures for 2004, OLADE (2006)) were used to make the following estimates:

- Production of bioethanol and percentage of bioethanol required for a 10% mix in gasoline by converting spent molasses, based on a productivity rate of 78 litres of bioethanol per ton of sugar produced (as from 8.8 litres of bioethanol and 112 kilograms (kg) of sugar per ton of sugarcane processed).
- Sugarcane-growing area required (in hectares, as a percentage of the current sugarcane-growing area and as a percentage of the total agricultural area) to promote

a 10% bioethanol mix in gasoline, based on a conservative productivity rate of 75 tons per hectare and a conversion rate of 80 litres of bioethanol per ton of sugarcane, corresponding to 6,000 litres of bioethanol per hectare.

Brazil was excluded from the analysis because it has already implemented a wide-ranging programme of bioethanol production and use, including pure bioethanol. The results can be seen in following table, which includes countries with more than one thousand hectares cultivated with sugarcane feedstock.

As the table shows, on average for the region, 35% of the biofuel requirement for a 10% bioethanol content in gasoline could be met either by using existing molasses or by increasing the current sugarcane-growing area by 22%, which is around 0.4% of the utilized agricultural area.

TABLE 8
POTENTIAL FOR MOLASSES CONVERSION AND REQUIREMENTS FOR SUGARCANE-GROWING AREAS FOR THE PRODUCTION OF BIOETHANOL TO MEET DEMAND FOR GASOHOL WITH A 10% BIOETHANOL CONTENT

Country	Data				Calculated values					
	Demand for gasoline ((SIEE - OLADE) 2004	*Sugarcane-growing area (FAOSTAT, 2005)*	*Total agricultural area FAOSTAT, 2005*	*Sugar production (FAOSTAT, 2005)*	*Demand for bioethanol for a 10% bioethanol mix (E10)*	*Supply of bioethanol from spent molasses*	*Supply of bioethanol from spent molasses*	*Sugarcane-growing area required to meet demand for bioethanol (sugarcane juice)*		
	Thousands of cubic metres	Thousands of hectares	Thousands of hectares	Tons	Thousands of cubic metres	Thousands of cubic metres	Percentage of demand	Thousands of hectares	Percentage of the current sugarcane-growing area	Percentage of the total agricultural area
Argentina	4 911.1	305	128 747	2 217 670	491.1	173.0	35	81.9	27	0.1
Barbados	124.4	8	19	36 325	12.4	2.8	23	2.1	26	10.9
Bolivia	763.4	105	37 087	433 615	76.3	33.8	44	12.7	12	0.0
Colombia	4 937.0	432	45 911	4 145 833	493.7	323.4	66	82.3	19	0.2
Costa Rica	855.1	49	2 865	391 500	85.5	30.5	36	14.3	29	0.5
Cuba	707.2	400	6 655	2 204 700	70.7	172.0	243	11.8	3	0.2
Dominican Republic	1 423.3	130	3 696	496 632	142.3	38.7	27	23.7	18	0.6
Ecuador	1 471.1	74	8 075	462 303	147.1	36.1	25	24.5	33	0.3
El Salvador	600.2	57	1 704	542 500	60.0	42.3	70	10.0	18	0.6
Guatemala	1 071.7	186	4 652	1 845 600	107.2	144.0	134	17.9	10	0.4
Guyana	130.0	49	1 740	302 378	13.0	23.6	181	2.2	4	0.1
Haiti	288.0	18	1 590	26 200	28.8	2.0	7	4.8	27	0.3
Honduras	457.2	76	2 936	337 728	45.7	26.3	58	7.6	10	0.3
Jamaica	699.8	40	513	153 542	70.0	12.0	17	11.7	29	2.3
Mexico	39 455.3	639	107 300	5 708 240	3.945.5	445.2	11	657.6	103	0.6
Nicaragua	248.9	45	6 976	461 810	24.9	36.0	145	4.1	9	0.1
Panama	576.7	37	2 230	158 778	57.7	12.4	21	9.6	26	0.4
Paraguay	202.5	74	24 836	170 000	20.3	13.3	65	3.4	5	0.0
Peru	1 203.6	58	21 210	1 004 813	120.4	78.4	65	20.1	35	0.1
Surinam	106.5	3	89	5 000	10.6	0.4	4	1.8	59	2.0
Trinidad T.	493.1	13	133	67 607	49.3	5.3	11	8.2	63	6.2
Uruguay	290.1	3	14 955	8 994	29.0	0.7	2	4.8	147	0.0
The Bolivarian Republic of Venezuela	12 700.6	130	21 640	751 000	1 270.1	58 6	5	211.7	163	1.0
Total	**73 716.9**	**2 618.6**	**316 793**	**19 678.7**	**6 868.1**	**1 534.9**	**22**	**1,144.7**	**44**	**4.0**

Source: ECLAC Natural Resources and Infrastructure Division, based on a working paper by Luiz Augusto Horta using data from FAOSTAT and the Energy Economic Information System (SIEE) of the Latin American Energy Organization (OLADE) (2006).

The above table illustrates the widely varying situations among countries. For instance, Cuba, Guatemala, Guyana and Nicaragua present great potential for producing bioethanol from molasses, in excess of the requirements for a 10% bioethanol mix in gasoline. At the other extreme, the sugarcane processing industry in Haiti, Surinam, Uruguay and the Bolivarian Republic of Venezuela is too small to produce even 10% of bioethanol requirements for a 10% mix in gasoline. From the land availability standpoint, the possibilities would seem to be endless as, with the exception of Barbados, Jamaica, Trinidad and Tobago, Surinam and the Bolivarian Republic of Venezuela, enough bioethanol could be produced for a 10% mixture by using less than 1% of the countries' agricultural area.

To form an idea of the investments required to produce bioethanol, assuming that agro-industrial plants are independent distilleries with a capacity of 450 m^3/day, each costing US$ 50 million, operating 210 days per year and 86% of the time, processing 1 million tons of sugarcane at each sugarcane harvest and producing 80,000 m^3 of anhydrous bioethanol, an estimated total investment of US$ 6.5 billion would be required to meet the bioethanol requirement for a 10% mix in all the gasoline consumed in those countries.

The estimated investment required for the productive development of sugarcane fields is US$ 3.25 billion, which means a total of US$ 9.85 billion for renewable bioethanol production equivalent to 65.4 million barrels of oil per year. Valuing gasoline at the earlier mentioned price of US$ 0.45 per litre, these distilleries would reduce by an annual 4.6 billion the demand for foreign exchange to import fuels (a common practice in virtually all the countries under study). Another important consideration is that these distilleries produce electricity and steam from available bagasse, with no need for external energy inputs and the potential to generate an annual surplus of 5,196 GWh from cogeneration systems.

As can be seen, practically all the countries in the region are cane-sugar producers with major agro-industries for manufacturing sugar and distillates, meaning that introducing bioethanol production would be nothing new, nor would it be a major technological leap, so the prospects for local production of this biofuel are considered promising.

III.2 Biodiesel: experiences in Latin America and the Caribbean

Whereas bioethanol has been produced and used in the region for almost a century, initiatives for the gradual adoption of biodiesel have been implemented only very recently in a few Latin American countries. Biodiesel is made by a process of transesterification of vegetable oils or other fats such as beef tallow. During this process, the vegetable oil is mixed with around 10% methyl or ethyl alcohol in the presence of an alkaline catalyst, which separates the glycerin and converts the fatty acids derived from oils or fats into esters with a similar density, viscosity and cetane number to mineral diesel. Biodiesel is suitable for use pure or in mixtures with mineral diesel for use in unmodified diesel-engine vehicles.

The prospects for biodiesel production have prompted public institutions and private firms in many countries to view biodiesel as an energy alternative that could be consolidated to make it widely adopted by the market, to a certain extent replicating the development of bioethanol in recent decades. In Latin America in particular, this would appear to be confirmed by the region's indisputable potential for producing oil-bearing crops and the impact of higher prices for crude-oil-derived fuels, most of which are imported. Below is a review of biodiesel promotion programmes currently being implemented in the region, with a detailed discussion of the most important economic and technological aspects of some of these programmes.

Argentina, one of the world's leading oilseed producers, recently launched a programme to promote biodiesel production and use, defining a timeframe and targets for the compulsory mixture. Soybean and sunflower crops are grown over wide expanses of highly productive land

and Argentina's vegetable oil industry is structurally an exporting one, sending around 90% of its production to the world market, with an installed capacity for processing 150,000 tons per day. The expected benefits from using biodiesel include reducing polluting emissions and creating jobs (SAGPA, 2006).

Prior to Law No. 26093 of 2005, mentioned earlier in connection with bioethanol, which created the Plan to promote the Production and Sustainable Use of Biofuels, Resolution 1156 of 2004 had launched the National Biofuels Programme, highlighting the prospects for biodiesel and promoting closer institutional links to boost research and increase investment. Law No. 26093 established the target of a 5% biodiesel mix in crude-oil-derived diesel by 2010, with regulations on a favourable tax regime, including a ten-year exemption from the fuel transfer tax (ITC) for biodiesel, by means of Decree 1396/2001. The law also created a programme management institution, as mentioned earlier in connection with the development of bioethanol in Argentina.

The biodiesel specification was defined in 2001 in the standards of Argentina's Standards Institute (IRAM), the body that lays down requirements and methods for biodiesel testing and for biodiesel marketing and supply in Argentina) and in Resolution No. 129/2001 of Argentina's Secretariat of Energy and Mining. It will be compulsory for the various plants which are planned to be brought into operation over the coming years to use bioethanol as the alcohol in biodiesel.

Although the complex issue of defining reference feedstocks does not appear to have been definitively decided, since it is planned to promote a number of different crops simultaneously, the majority of studies are on soybean and secondly on sunflower. The following table shows the crops under consideration and their main parameters for biodiesel production. Note that the energy balance shown in the table is the difference between biodiesel production and demand for diesel in farming activities, without considering indirect energy costs, transportation and processing, although they can represent a very high proportion of total energy costs. As the values in the table show, soybean, for which direct cultivation was considered, is the feedstock with the lowest energy productivity and the least attractive energy balance.

TABLE 9
INDICATORS FOR BIODIESEL FEEDSTOCKS IN ARGENTINA

Crop	*Yield (kg/hectare)*	*Oil yield from seeds (%)*	*Biodiesel yield (litres/hectare)*	*Energy balance (litres/hectare)*
Jatropha	2 500	55	1 419	1 369
Castor	2 500	48	1 239	1 187
Rape	2 400	47	1 164	1 115
Sunflower	1 950	40	805	754
Soybean	2 700	18	502	477

Source: Argentina's Secretariat of Agriculture, Livestock, Fisheries and Food (SAGPA), 2006.

According to studies of requirements for achieving the target, demand for diesel in Argentina in 2010 will be around 13.7 million m3, which will require 685 million litres of biodiesel (around 600 million tons), derived from processing 3.5 million tons of soybeans per year (9% of Argentina's production), harvested from around 1.3 million hectares of soybean crops (SAGPA, 2006). With regard to investments, approximately 18 biodiesel plants would be required, at a cost of US$ 8 million for each plant with a production capacity of 40,000 tons of biodiesel per year, corresponding to a total industrial investment of US$ 144 million (SAGPA, 2006).

In **Brazil**, initiatives for promoting the use of vegetable oils in diesel engines have been in place since 1920, with limited success. The most important programmes, proposed at almost the same time as bioethanol was adopted, were Pro-óleo and the vegetable oil programme, OVEG, in 1980, which also had limited success. In 2002, the matter was taken up again, and Brazil's national biodiesel research and technology programme (PROBIODIESEL) was set up, coordinated by the Ministry of Science and Technology, which started to reconcile the various interests and to discuss the biodiesel specification for Brazil. It is important to find renewable substitutes for diesel in Brazil, since this is the crude-oil-derived fuel with the highest consumption. Demand for diesel is approximately 36 million m^3 per year. Around 10% of this volume is imported for use mainly in the transport sector (80%) and electric power generation in isolated systems, mostly in the Amazonia region of Brazil (Brazil's Ministry of Mines and Energy (MME), 2006).

In November 2003, the Brazilian Government launched its Biodiesel Programme, with production targets and incentives for small producers. In 2004, the ANP (formerly known as the National Oil Agency but now as the National Oil, Natural Gas and Biofuels Agency), defined the biodiesel specification regulating biodiesel production and marketing (ANP Resolution 42/2004). Law No. 11097/2005 made it compulsory to add a minimum 2% biodiesel to all diesel sold in Brazil after 2008, rising to a 5% target in 2013. Subsequent legislation then lays down the phases for integrating biodiesel and for support mechanisms, basically promoting family farming and the least developed regions (north and north-east), as the following table shows.

TABLE 10
FEDERAL LEVIES IMPACTING ON BIODIESEL IN BRAZIL

	Crude-oil-derived diesel	*Biodiesel in general*	*Biodiesel from castor or palm in the north/north-east*	*Biodiesel from feedstocks with the "Social Fuel" seal*	*Biodiesel from castor or palm in the north/north-east and the "Social Fuel" seal*
Reduction coefficient	0.0000	0.6763	0.775	0.896	1.000
Levies (Brazilian reals per cubic metre)	673.33	217.96	151.50	70.03	0.0

Source: Abreu and Guerra, 2006.

Brazil's federal states also impose value-added tax (VAT) on diesel of approximately 0.244 Brazilian reals per litre, although VAT on biodiesel is now being reduced as an additional tax incentive. When biodiesel producers use feedstock from family farms, they are awarded the "Social Fuel" seal in accordance with the rules of the Ministry of Agrarian Development.

For this type of biodiesel, the Government brought forward the target for compulsory biodiesel content to early 2006, in line with available biodiesel supplies, to be tendered in ANP calls for tender. The ANP defined the maximum reference price and the amount to be marketed by diesel producers, who conclude purchase contracts for the biodiesel to be mixed with the product which they are required to distribute. Four ANP calls for tender were made and the following table summarizes the results (Ardenghi, 2006).

Table 11
RESULTS OF ANP CALLS FOR TENDER FOR BIODIESEL

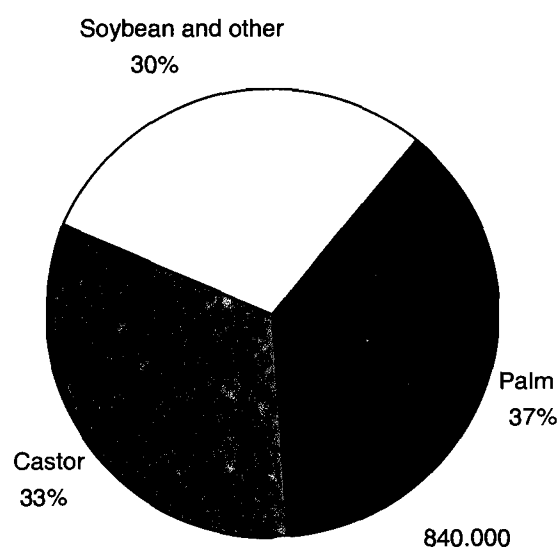
Date	*Volume marketed (cubic metres)*	*Average price (Brazilian reals per cubic metre)*	*Delivery date*
21/11/05	70 000	1 904.84	2006
30/03/06	170 000	1 859.65	2006/2007
11/07/06	50 000	1 753.79	2007
12/07/06	550 000	1 746.66	2007

Source: Ardenghi, 2006.

Although the volume of biodiesel committed in ANP calls for tender just about meets the estimated demand for 2007 to achieve the target of a 2% biodiesel in the mixture (around 800 million litres of biodiesel), there is good reason to doubt that the deliveries will actually be forthcoming. In view of the regional distribution of the winning bids in the calls for tender and the most suitable crops for each region, as well as the precedence given to producers with a "Social Fuel" seal, an estimated 33% of the potential biodiesel supply will use castor as the feedstock.

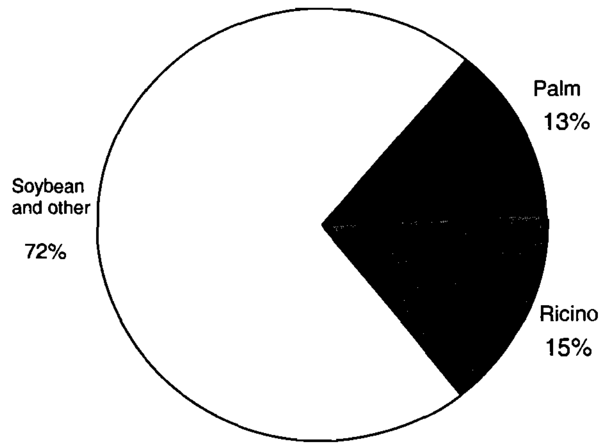
A large share of biodiesel production is therefore based on a crop that is currently very limited and on production from family farms, which will require new plantations for which the extension and technological support mechanisms are still being implemented. In addition, as can be seen below, the majority of processing plants for producing biodiesel are still on the drawing board. However, in the latest tender there was a marked drop in biodiesel prices to around US$ 0.79 litre.

FIGURE 18
DISTRIBUTION OF BIODIESEL SUPPLY FOR EACH FEEDSTOCK IN ANP CALLS FOR TENDER



Source: estimation, Ardenghi, 2006.

FIGURE 19
DISTRIBUTION OF AUTHORIZED BIODIESEL PRODUCTION CAPACITY IN BRAZIL, BY FEEDSTOCK



Source: ANP, July 2006.

As the following table shows, the biodiesel production capacity authorized by the ANP up to July 2006 is 185 million litres per year (based on biodiesel plants being in operation 300 days per year). However, this figure does not adequately reflect the highly dynamic authorization processes under analysis – around 29 new plants (Ardenghi, 2006). Neither does it reflect the production capacity actually available, since many of these plants are still in the process of implementation. The current annual production capacity of biodiesel in Brazil is estimated to be 60 million litres and may well exceed 1.2 billion litres by 2010 (Khalil, 2006), with projected investments of US$ 195 million during that period (Abreu, 2006).

TABLE 12
AUTHORIZED CAPACITY FOR BIODIESEL PRODUCTION IN BRAZIL

Company	*Location*	*Authorized capacity (cubic metres/day)*	*Estimated annual capacity (thos. Cubic mt/year)*	*Predominant feedstock*
Soyminas	Cássia (State of Minas Gerais)	40	12	Soybean
Agropalma	Bélem (State of Pará)	80	24	Palm
Brasil Biodiesel	Teresina (State of Piauí)	2	0.6	Castor
Biolix	Rolândia (State of Paraná)	30	9	Soybean
Brasil Biodiesel	Floriano (State of Piauí)	90	27	Castor
NUTEC	Fortaleza (State of Ceará)	2.4	0.72	Castor
Fertibom	Catanduva (State of São Paulo)	20	6	Soybean
Renobras	DomAquino (State of Mato Grosso)	20	6	Soybean
Granol	Campinas (State of São Paulo)	133	39.9	Soybean
Granol	Anápolis (State of Goiás)	200	60	Soybean

Source: ANP, 2006.

A system was implemented for monitoring biodiesel quality and, according to ANP assessments, up to now all the biodiesel delivered to the market has complied with specifications. Since biodiesel brings tax benefits, the ANP implemented a system for marking this biodiesel using a chemical tracer to rapidly check whether or not the diesel contains the biodiesel mix (Souza, 2006). Distributor firms have shown interest in supplying biodiesel to their customers, as it is a positive commercial differentiation factor for them, chiefly because of the environmental impact of biodiesel (ALESAT, 2006).

The wide-ranging potential for oil-bearing crops in Brazil, as well as in Argentina, highlights the crucial issue of defining the best alternatives for biodiesel production. The following table shows, from a Brazilian perspective, the biodiesel productivity levels for each hectare of a group of crops. Since a significant variation can be observed, sooner or later it will steer production towards the most efficient feedstocks. To give an idea of the importance of this issue, to satisfy the predicted demand for biodiesel for a 5% mixture in current diesel consumption in Brazil (around 5 billion litres of biofuel), 3.3 million hectares of soybean, 2 million hectares of castor and 0.4 million hectares of palm would be needed (Horta Nogueira, 2005).

Table 13
OIL-BEARING CROPS OF IMMEDIATE INTEREST FOR BIODIESEL IN BRAZIL

Crop	*Oil yield (tons/hectare/year)*	*Required crop area to produce one ton of oil (hectares)*
Castor	0.7	1.43
Soybean	0.6	2.00
Peanut	0.7	1.43
Babassu	0.12	8.33
Palm	5.0	0.20

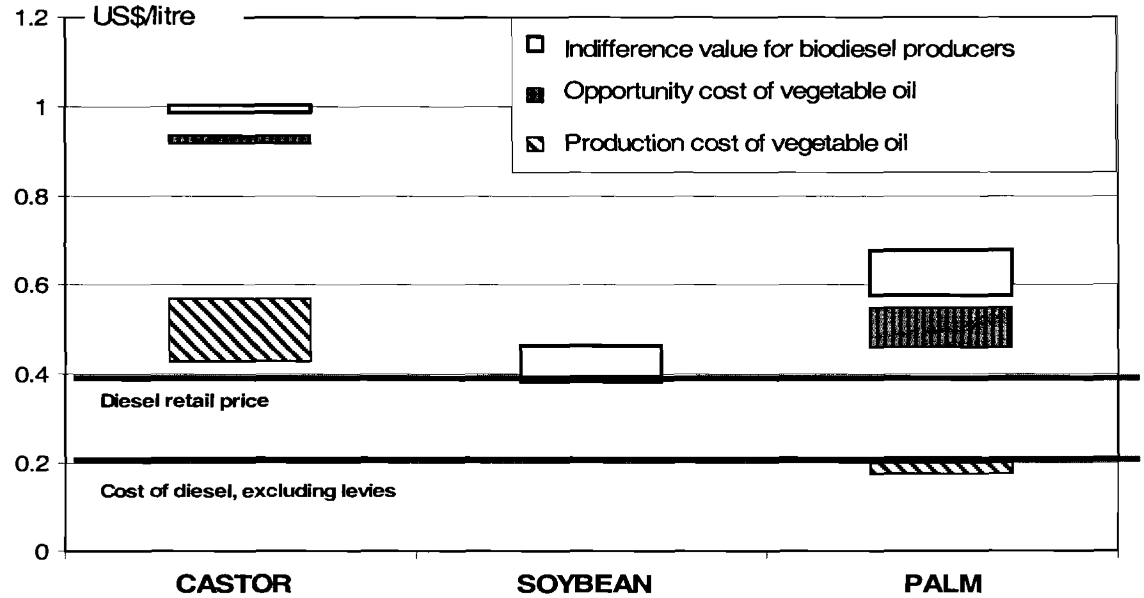
Source: Rocha, 2005.

As regards biodiesel costs in Brazil, to an even greater extent than bioethanol, the feedstock (such as vegetable oil) represents the bulk of the cost - as much as 85% of the final cost of the biodiesel (CGEE, 2005). So, understandably, cost studies for Brazilian conditions report that there is strong specificity depending on the feedstock and the production region. For example, for soybean-derived biodiesel, the production costs for crops from São Paulo and Paraná range from US$ 300 to 380 per cubic metre and for central Brazil, from US$ 770 to 830 per cubic metre, whereas for castor, estimated costs are approximately US$ 800 per cubic metre (Rocha and Cortez, 2005).

Naturally, these biodiesel production costs must be compared with the opportunity cost of other products that can be made from the same feedstocks. They must also be compared with the market price for biodiesel, always taking into account levies and earnings from any by-products like high-protein oil cake for use in animal feed.

The results of an exercise on the competitiveness of biodiesel from different feedstocks under Brazilian conditions indicated that castor is not very attractive, whereas palm shows marginal competitiveness owing to its significantly lower opportunity costs, as the following figure shows. No data was presented on the costs of producing biodiesel from soybean because of its clear dependency on the price of oil cake (CGEE, 2005).

FIGURE 20
COMPETITIVENESS OF BIODIESEL FROM DIFFERENT FEEDSTOCKS



Source: CGEE, 2005.

In **Colombia**, Law No. 939 of 2004 formalized interest in biodiesel. It "... promotes the production and marketing of plant- and animal-derived biofuels for use in diesel engines and lays down other provisions...", as well as promoting tax exemptions and setting up a National Biofuels Forum (Mesa Nacional de Biocombustibles) to allow public and private institutions with experience and/or interest in developing biodiesel to work together and also to define and develop the technical, economic, regulatory, logistical and environmental strategies needed for the sustainable promotion of biodiesel in Colombia.

In another important measure, Resolution 181780 of 2005 establishes a price signal, based on feedstock costs and a purchase guarantee by diesel distributors for a mixture containing 10% biodiesel as a way of ensuring cost recovery. The aim is for the programme to begin "in June 2008 at the latest" (UPME, 2006). An estimated 300,000 tons of palm oil would be needed annually in order to introduce a 10% biodiesel content into the Colombian market (roughly 50% of current national production), requiring around 100,000 hectares of African palm and creating more than 100,000 direct and indirect jobs. In a feasibility study for a plant to be installed in Barrancabermeja with an annual capacity of 150,000 tons, the investments were estimated at US$ 16 million, with a biodiesel producer price of US$ 1.25 per litre based on a feedstock (palm oil) cost of US$ 320 per ton (Cala Hederich, 2003).

By means of Decree No. 31818-MAG-MINAE of 2003, the **Costa Rican** Government created a Technical Committee comprising public institutions (Ministry of Agriculture and Livestock, Ministry of Environment and Energy and the state oil company, RECOPE) and private institutions (CANAPALMA, the national oil palm and oleochemical industry) to formulate, identify and design strategies for developing biodiesel which, "if the results of the studies turn out to be positive", will table the necessary legislation (Musmanni, 2006). In a study on the opportunity of palm-derived biodiesel, it was determined that there was little public interest and that it was heavily dependent on conventional diesel prices, so it is decisive for feasibility studies to consider the positive externalities of biodiesel. For instance, under the average conditions of the reference scenario for a standard project in Costa Rica, the internal rate of return was estimated to be -1.41% excluding externalities, whereas the figure was 41.3% including externalities (Musmanni Sobrado, 2005).

In practical in terms, interest in biodiesel grew in **Honduras** as from 2003. For instance, a biodiesel production plant was installed in Tocoa, on the Atlantic coast, with a production capacity of 20 tons per day and plans to expand this to 100 tons in the short term, using palm oil as feedstock. The cost of biodiesel in this production plant was reported to be US$ 01.61 per litre, which allows its 5% mixture with diesel to be delivered at a cost of US$ 0.704 per litre to a small group of consumers. This is enough to wean them away from paying US$ 0.778 per litre for conventional diesel. Although it is a small-scale private pilot project, it is making it possible to test the production and use of an innovative biofuel with success up to now, although the specific legal framework has not yet been fully developed (ECLAC, 2006).

Nicaragua is perhaps the most advanced country in the region in terms of exploring non-conventional biodiesel feedstocks. In an experiment described in greater detail in a previous study (ECLAC, 2004), a jatropha methyl ester project (EMAT) was conducted in Nicaragua in the early 1990s with support from the Austrian Government, after conducting feasibility studies and agricultural research into *Jatropha curcas L.* (known locally as *tempate* or *piñón*). The project aimed to "lay the foundations for the industrial processing of jatropha, obtaining biodiesel, reducing dependency on imported energy, making foreign exchange savings, protecting the environment and creating job opportunities" (Ocampo, 1993).

The project involved planting 1,013 hectares of jatropha and a processing plant was set up to turn the seeds into biodiesel (with a capacity to process 8,000 tons of seeds per year), calculating that the whole cultivated area would produce 7,100 barrels of diesel per year (around 1,130 litres of biodiesel per hectare). This was expected to represent less than 1% of the diesel market and would be sold at US$ 0.22 per litre, which was the wholesale price of the crude-oil derivative, and would guarantee the project a minimum return. Note that this was a pilot project to improve research and possibly promote an alternative energy supply that could ultimately "replace 10% of imported diesel" (*Ibid*, 1993). There was preliminary planning of the agricultural component, involving the establishment of nurseries and plantations and the definition of a harvesting procedure. However, it did not prove possible to stabilize agricultural production and, after a few years of operation and a cost of around US$ 3 million, the project was abandoned.

The professionals involved in this project unanimously agreed that the industrial component had worked well but that the agricultural component had failed owing to poor management and to rural producers' low level of commitment to the project. Continuing support for the project was warranted by its major social impact, not least because it provided jobs for displaced persons at the end of the civil war in the 1980. This meant that the aim of the agricultural production model was in fact to meet a serious and pressing social need, giving no priority to efficiency or to setting incentive mechanisms to increase productivity. What had started off as a pilot project to assess an energy alternative in a sense turned out to be a peace-keeping operation to provide short term social welfare, rather than an agricultural product capable of promoting development. Project professionals also agreed that if any further attempt is made to produce biodiesel using jatropha, agricultural production would need to be on a larger scale and more modern technology would need to be introduced (ECLAC, 2004). Another point of note is that the reference price for diesel was significantly lower in that period than it has been in recent years.

In recent years, **Peru**'s La Molina National Agrarian University has been conducting a major study on the productivity and suitability of Amazonian oil-bearing plant varieties with potential for biodiesel production. Interesting conclusions were made on hitherto virtually unknown plant varieties and models of small-scale transesterification plants were tested, in addition to conducting bench tests on diesel engines (Castro et al, 2005).

Virtually all the other countries in the region have implemented a wide array biodiesel initiative. For example, in **Guatemala,** the Octagón Company reported that it had planted 2,500 hectares of jatropha for the extraction of oil for biodiesel production (Asturias, 2006). In **Paraguay**, although Law No. 2748 of 2005 still does not stipulate the percentage of biodiesel to be blended with diesel, it does state that mixing is compulsory. In the **Dominican Republic,** which already grows more than 8,000 hectares of palm, there are plans to expand this crop for biodiesel production, estimating that a 20% biofuel content in diesel would lead to a biodiesel requirement of approximately 265.6 million litres in 2010 (CNE, 2006).

In a preliminary exercise on the **potential of countries in the region to produce biodiesel**, a study was made of the size of exports of the two most important oil-bearing products in the region (soybean, which yields 18% of its weight in oil, and palm, which yields 20%), based on data for 2004 (FAOSTAT, 2006), as exports could be considered to represent the difference between production and domestic consumption values. The volume of biodiesel that could be produced from these exports was calculated, assuming a 1:1 ratio between oil consumption and biodiesel production and a density of 0.80 kg/litre.

The following table shows the results for countries where this type of analysis yielded significant results. The results are given in absolute and relative terms, compared with the diesel consumption actually recorded in these countries in the same year (OLADE, 2006).

TABLE 14
POTENTIAL BIODIESEL PRODUCTION FROM SOYBEAN AND PALM OIL EXPORTS

Country	*Potential for biodiesel production*	
	(Thousands of cubic metres)	Percentage of diesel requirements
Argentina	8 197.1	66
Barbados	1.5	3
Bolivia	307.5	55
Brazil	9 827.8	26
Colombia	180.8	4
Costa Rica	132.3	15
Ecuador	66.6	3
El Salvador	2.7	0
Guatemala	60.9	5
Honduras	119.6	14
Mexico	2.2	0
Nicaragua	1.3	0
Panama	3.1	0
Paraguay	625.6	58
Uruguay	58.8	7

Source: ECLAC Natural Resources and Infrastructure Division, based on a working paper by Luiz Augusto Horta using data from FAOSTAT and the Energy Economic Information System (SIEE) of the Latin American Energy Organization (OLADE) (2006).

The results in the above table, which basically compares the size of oil-bearing feedstock exports with the total number of diesel-powered vehicles for various countries, show Argentina, Bolivia, Brazil, Costa Rica, Honduras and Paraguay to be the countries with the greatest potential supplies of biodiesel – the very countries with relatively large exports of such agricultural products.

There is reason to believe that many of the outstanding biodiesel issues will be resolved in the medium term (such as selecting the most appropriate feedstocks, defining the most efficient and cost-effective models, as well as optimizing the energy and economic aspects of agro-industrial conversion). This would allow biodiesel to be expanded sustainably in Latin America and the Caribbean, exploiting the region's enormous potential for biofuels.

III.3. Future challenges for the sustainable development of biofuels in Latin America and the Caribbean

Up to now the main aim of this chapter has been to provide an overview of programmes for promoting bioethanol and biodiesel in a few Latin American countries, throwing more light on differences between these two biofuels in terms of production potential and economic feasibility. The result would tend to favour bioethanol rather than biodiesel, at least in the short to medium term.

(A) Challenges for bioethanol

There is ample experience with sugarcane cultivation worldwide, with more than 100 countries growing it at present. However, none has such a favourable cost structure as Brazil. Whereas the average cost of producing sugar in Brazil (in 2005) was around US$ 65 per ton, only about one quarter of world production had an associated cost of between US$ 90 and 115 US per ton (while for the rest of the world, the cost production was in excess of US$ 180 per ton). For instance, Australia, with a sugar production cost of around US$ 85 per ton (exceeding only Brazil and Thailand (90 US$)), could make bioethanol production profitable without government support only if world oil prices stayed at current levels.

Latin America is one of the few regions in the world to have such favourable potential for bioethanol production, with plenty of available land, a conducive climate and a long sugarcane growing tradition, combined with a need to reduce energy dependency rates, to introduce renewable and less polluting fuels and, at the same time, to create jobs and to revive rural areas. As the various initiatives to develop bioethanol production programmes in the countries of the region show, prospects for expanding the use of bioethanol can be considered alluring to say the least.

In general, it cannot be said that any major barriers exist to the development of bioethanol in the region, apart from poor information on the advantages and drawbacks producing bioethanol and the basis for sustainable production.

Indeed, the lack of information on bioenergy systems and the importance of securing agro-industrial productivity and a net positive energy balance explain why proposals for implementing bioethanol programmes based on low-energy crops continue to go ahead, even when they are not fully justified. It is therefore crucial to choose crops and conversion technologies in line with economic and environmental sustainability criteria. In this respect, the use of maize, for example, ought to be carefully considered in Latin America and the Caribbean. In the United States, the insistence on producing biofuel with low energy productivity cost the Treasury Department US$ 3.3 billion in direct subsidies in 2004 to make production viable (Patzek, 2005).

It is therefore important to promote information programmes to publicize the advantages and drawbacks associated with the production and efficient use of bioethanol, whilst acknowledging the diverse views and objectives of social and economic operators, so as to achieve the crucial consensus needed for a gradual transition from fossil-based primary energy resources to renewable resources. In any case, for it to be effective and sustainable, any decision to maintain or increase bioethanol production must be the result of careful consultation among the various interests, with the welfare of society as a whole as the primary goal.

An important factor to emphasize is that, with the exception of Brazil, large-scale biofuel production has only proven to be feasible, with certain guarantees, in eminently industrialized countries. Brazil's bioethanol industry is mature, with a highly favourable cost structure, and could expand significantly in the future in response to growing demand. The most important question is how far the Brazilian bioethanol experience can be replicated. As this study goes to press, it is an issue that is being analysed in Chile, to cite but one example.

The key questions analysed in the document "Potential for Biofuels for Transport in Developing Countries" published by ESMAP[8] in 2005 are still relevant:

- Could the bioethanol industry (and the biofuel industry in general) be financially viable without government support?
- Is such support justifiable in certain cases?
- Which factors affect the financial and economic viability of programmes for producing (or expanding the production of) bioethanol?

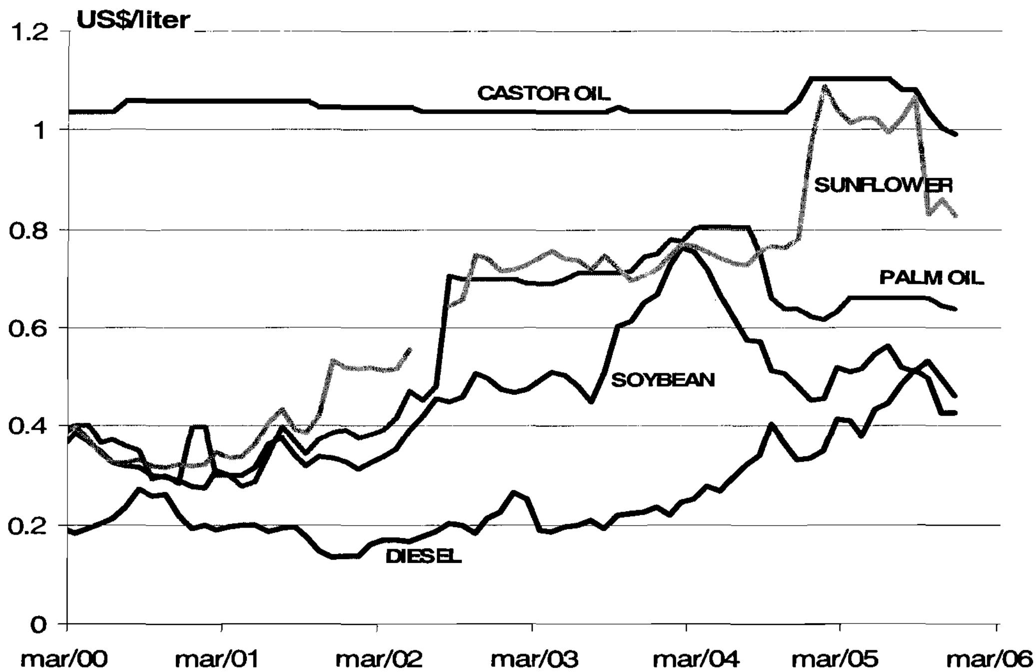
(B) Challenges for biodiesel

Biodiesel could be turned into an effective substitute for crude-oil-derived diesel, but first its real feasibility needs to be irrefutably demonstrated, especially in energy balance and productivity terms. Europe's experience with biodiesel comes from agricultural policies that are hard to replicate in Latin America and the Caribbean, with heavy subsidies and strict customs barriers. The development of bioethanol in Brazil over the decades can serve as a useful counter-model of reference to avoid repeating past mistakes such as excessive interventionism, ill-chosen feedstocks, a failure to recognize the importance of integration and flexibility for agro-industry, and delays in promoting agricultural development.

In terms of the financial viability of biodiesel, it is useful to analyse the trend in international prices for vegetable oils and diesel in recent years, translated into comparable bases, as the following figure shows. The values for biodiesel were estimated on the basis of prices free on board paid to vegetable oil producers (Economic Research Service (ERS), 2006), assuming a density of 0.80 kg/litre and a vegetable oil cost of roughly 80% of the total cost of producing biodiesel. For diesel, prices in the Rotterdam spot market were taken (Energy Information Administration (EIA), 2006).

8 The Energy Sector Management Assistance Program (ESMAP) is a joint effort between UNDP and the World Bank, established in 1983. The main objective of ESMAP is to guarantee that energy contributes to poverty reduction and to environmentally responsible economic growth.

Figure 21
REFERENCE PRICES FOR BIODIESEL FROM DIFFERENT FEEDSTOCKS AND FOR "ROTTERDAM DIESEL"



Source: Economic Research Service (ERS), 2006 and Energy Information Administration (EIA), 2006.

As the above figure shows, vegetable oil prices have been systematically higher than the price of diesel so, when proposing to use a vegetable oil as fuel, apart from making sure that it costs less than the selling price (whether or not compensation, tax waiver or subsidy mechanisms are used), it is essential to find out whether an alternative use exists that would yield higher profits, that is to say, whether there is an opportunity to add more value to the product.

One way to define opportunities for increasing the feasibility of biodiesel is therefore to identify uses with greater added value. Biodiesel is usually proposed because of its potential environmental benefits in reducing emissions, with other aims being to substitute imported diesel or to boost the agro-industrial sector. Biodiesel can also be used as an additive to improve the lubricity of diesel, which is increasingly jeopardized by reductions in sulphur content. There is reason to believe that, starting with the most value-added uses for biodiesel and integrating it into energy structures, its poor performance will be improved to make it better able to compete with mineral diesel.

(C) Cost-benefit analysis: a key factor for promoting biofuels

There is no doubt that only a complex economic analysis is capable of analysing the wide range of issues raised above with the minimum rigour required. In this respect, the ESMAP document aptly states that: "... such an analysis may not provide a definitive answer to the question of whether or not domestic production of biofuels will bring net social benefits... There are large uncertainties arising from lack of data and a large number of assumptions that have to be made:

future prices of biofuel feedstocks and crude oil, advances in technology and decline in future production costs, to name a few. Nevertheless, calculations using available data and reasonable assumptions will make costs and benefits transparent and facilitate a public debate on how best to use public funds..." (ESMAP, 2005).

Indeed, any analysis of biofuel production viability would need to be part of an analysis of social costs and benefits (which should include a financial viability analysis, an efficiency analysis and an equity analysis). Only this would provide a clear enough picture to enable public decision-makers to accurately ascertain whether government support is justified in such circumstances where, as expected, biofuel production is not profitable otherwise (even with high oil prices).

This calls for an analytical framework that studies such issues as the benefits for rural development (consolidation of property rights, dismantling of trade barriers, investment in education and health, agricultural research and extension, water supplies, electricity supplies and better transport infrastructure); the integration of environmental externalities (such as those deriving from avoided emissions of regional or local pollutants and greenhouse gases); the diversification of the energy structure, and so on.

ESMAP (2005) states that, even where there are positive returns, government support for biofuels as an infant industry should be temporary, or else in the long run the policy will result in inefficient allocation of resources in the economy as a whole.

For investment in the biofuel industry to be sound and advantageous to society as a whole, it is essential to properly manage variability in oil and feedstock prices (in competition with food production), and to conduct fairly unrestrictive economic analyses that include all the major analytical factors. In the short term, sugarcane-derived bioethanol might be the best alternative because of its commercial viability.

However, amongst other things, sugarcane production would require a large supply of water, as well as a tropical climate. In the medium term, the situation will vary predictably: the costs of producing biofuel in general, and bioethanol in particular, will fall and other feedstocks are likely to become viable. With fewer climatic and water consumption requirements, this could well make biodiesel more cost-effective. In the long term, the new "second generation" biofuels herald much promise. Some of these, including Fischer-Tropsch biodiesel, methanol and, in particular, bioethanol derived from lignocellulosic crops, could reduce many of the external costs associated with biofuel production and are much cheaper to produce.

(D) Role of the public sector in promoting biofuels

It would make sense for the public sector to be actively involved in the biofuel sector for a number of reasons: to eliminate regulatory barriers to investment in biofuels; to raise public awareness of the proper use of biofuels and to analyse the external costs that biofuel production would impose on society as a whole. ESMAP (2005) emphatically recommends conducting complex economic analyses to evaluate the financial, economic and social viability of biofuel production and to analyse possible government support for it.

This means addressing climate concerns (and optimizing decisions on which feedstock to be used in each case), whilst evaluating the transport and communications structure, each country's applied research capacity and technological development, the educational level of the agricultural labour force engaged in producing bioethanol feedstocks, the robustness of the credit system, the soundness of management (in both the agricultural and agro-industrial phases) and mechanisms for internalizing certain environmental externalities (arising from atmospheric pollution in urban areas or greenhouse gas emissions, for instance).

The sustainable development of biofuels (both bioethanol and biodiesel) in Latin America and the Caribbean will therefore call for a major concerted multisector effort by the Governments of the region. This should aim to lay sound foundations for the design of national plans to promote biofuels.

A national plan for the sustainable development of biofuels must meet a number of multidimensional challenges, answering questions such as:

- How to define better, technically robust and sufficiently tested alternatives, with clearly defined indicators of agricultural, industrial, and energy productivity and of economic feasibility?
- Which parameters should be used as a basis for making complex analyses and prioritizing objectives, endeavouring to expand the universe of beneficiaries without creating dependencies and raising expectations? For example, it is always desirable for small and medium producers to have access to the biofuel market, but in a balanced way without preventing other producers from participating. Similarly, the promotion of regional development and job creation should not be afforded greater priority than the production of biofuel itself.
- How to prepare carefully for the introduction of the new fuel, acknowledging possible conflicting interests and endeavouring to achieve the minimum level of consensus required? In that respect, it is essential to have government leadership and decision-making, as well as to inform stakeholders, as recent experiences with introducing bioethanol into Colombia and Costa Rica have amply demonstrated.
- How can specifications be established for pure and blended fuels, as a key measure for guaranteeing consumer rights, reducing pressures from fuel distribution firms and guiding productive investment?
- How can logistical and storage conditions be assessed, leaving it up to administrators, within defined time limits, to systematize procedures for blending and for monitoring quality?
- Which political and technical processes must be used as a basis for establishing a clear legal framework that is consistent with the fuel market? In this respect, efforts should be geared to: (i) limiting intervention in price setting as much as possible; (ii) guiding the balanced distribution of the fuel's added value among the production sectors concerned; (iii) reducing risks, especially by defining a minimum biofuel content in the mixture, with an implementation schedule.
- Which factors should be used as a basis for exploring the usefulness of adopting mechanisms for "internalizing" externalities (for example by means of clear-cut differential tax waivers among energy products, since revenues from fuel levies are major sources of funding for Governments)?
- How to properly monitor and evaluate the programme on a continual basis jointly with the stakeholders involved?

Chapter IV
The carbon market and renewable energies in Latin America and the Caribbean: status and prospects

IV.I Introduction to the carbon credit market

The Kyoto Protocol was launched in 1997 at the third meeting of the member countries of the United Nations Framework Convention on Climate Change (UNFCCC). The Protocol lays down the architecture of the international market for greenhouse gas emission reductions (called the "carbon market"). The carbon market's demand for emission reductions has been established by the quantified emission limits assigned to the industrialized countries (known as the Annex 1 countries),[9] and the market mechanisms for meeting these commitments in a cost-effective manner.

The three market mechanisms created by the Kyoto Protocol (Emissions Trading, Joint Implementation and the Clean Development Mechanism (CDM)) allow Annex 1 countries not only to take domestic measures for reducing emissions but also to buy emission reductions from other countries.

The CDM is a mechanism for trading project-based emissions, which is of special interest to the Latin American and Caribbean countries as it enables developing countries to sell emission reductions to Annex 1 countries. Since the Kyoto Protocol establishes that developing countries do not have to meet emission targets, such emission-reduction projects are voluntary. For emission reductions to be eligible for the CDM, projects must prove that, in addition to reducing emissions above a certain baseline, the economic incentive provided for in the CDM is crucial to the project's development.

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[9] Industrialized countries listed in the Kyoto Protocol with commitments to reduce greenhouse gases. The targets for greenhouse gas reductions or limitations are defined by 38 developed countries and for the European Union as a block. These targets are listed in Annex B of the Protocol. In total, an average reduction of 5.2% per year has been established for the first commitment period (2008-2012) compared with emissions in the base year 1990. Source: Caring for Climate. A guide to the Climate Change Convention and the Kyoto Protocol. UNFCCC (2005), page 25.

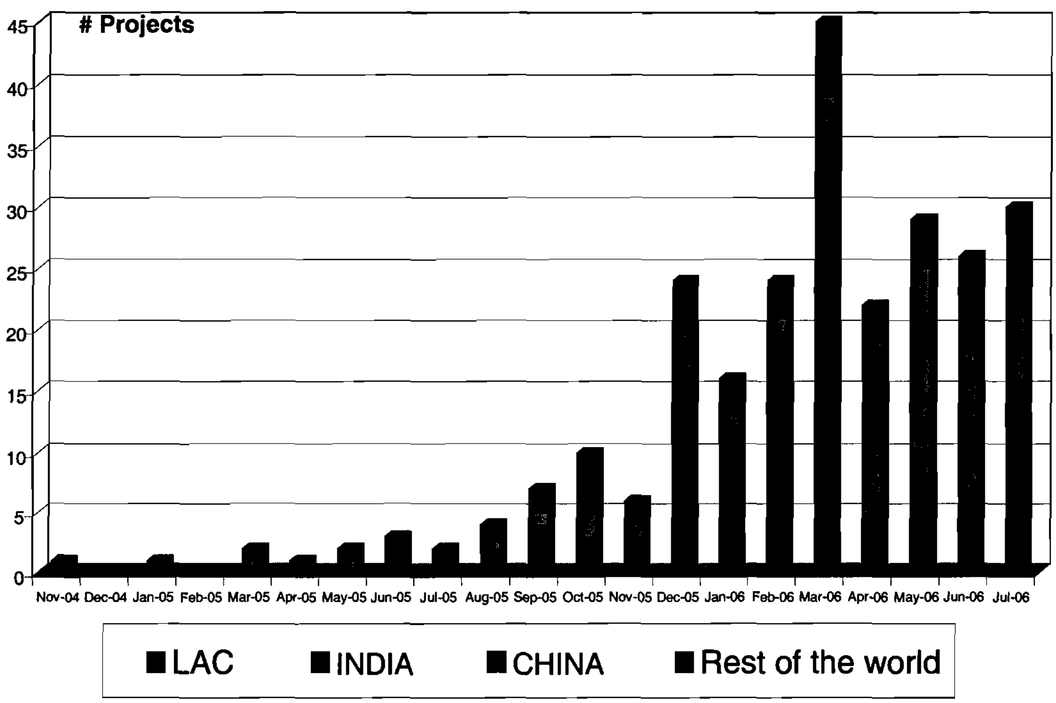
The CDM has been designed to achieve two goals: (i) to contribute to the sustainable development of developing countries and at the same time (ii) to increase Annex 1 countries' chances of meeting their Kyoto commitments. Traded emission reductions are known as Certified Emission Reductions (CER).

IV.2 The region's importance in the world CDM market

(A) Trend in registered projects

For a project to be authorized to sell CERs it must be registered by the CDM Executive Board of UNFCCC. Registration is subject to the project complying with the eligibility requirements established by the United Nations as part of the Kyoto Protocol. The project registration process had received so much criticism for its excessive complexity and unwieldiness that, by July 2005, five months after the Kyoto Protocol came into force; only 12 CDM projects had been registered. However, the monthly rate of CDM project registration has taken off in recent months and, by August 2006 there were already 259 registered CDM projects, 49% of which (127 projects) were Latin American. The following figure shows the monthly trend in registration, starting with the first registered project and ending in August 2006.

Figure 22
TREND IN CDM PROJECTS REGISTERED PER MONTH BETWEEN NOVEMBER 2004 AND AUGUST 2006



Source: ECLAC Natural Resources and Infrastructure Division, based on a working paper by Lorenzo Eguren using data from the UNEP Risø Centre on Energy, Climate and Sustainable Development (June 2006) and information from the United Nations Framework Convention on Climate Change (August 2006).

A number of factors have helped to speed up registration of CDM projects.

Since the Kyoto Protocol came into force, many member countries, and especially the European Union countries, have been pressuring the CDM Executive Board to speed up the project approval and registration process, and the Annex 1 countries have promised to increase funding to the Executive Board.[10]

- The Executive Board has been more flexible in approving projects and a funding increase has improved its operational capacity.
- A critical mass of approved methodologies and registered projects has created the methodological basis and experience required for speedier approval of similar projects.
- The widespread use of the additionality tool proposed by the Executive Board has reduced the uncertainty of project additionality criteria and interpretation, a key factor in deciding the eligibility of projects for the CDM.
- The cumulative build-up of CDM projects awaiting registration had reached unacceptable proportions (even though 259 projects have been registered, 601 projects were still queuing up for registration in August 2006, many of which had been applying for years).
- It is hoped that this sudden increase in project registrations will even out to a stable monthly number once the backlog of projects applying for registration has been reduced.
- The majority of developing countries, especially in Latin America, have completed the process of establishing their Designated National Authority (DNA) and procedures for obtaining the letter of approval from the host country.
- After the Kyoto Protocol came into force, countries like India and China defined their institutional and regulatory frameworks for developing the CDM, which increased the influx of CDM projects dramatically.

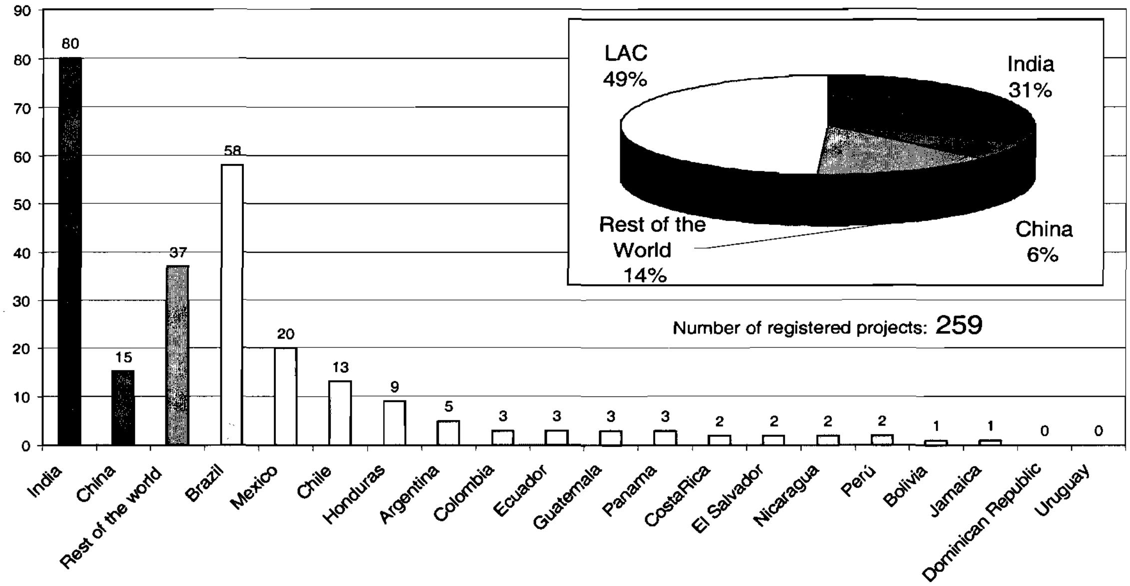
(B) Number and volume of registered projects in the region

By early August 2006, a total of 259 CDM projects had been registered, meaning that the CDM Executive Board had approved 259 projects for selling CER under the Kyoto Protocol. Latin America continues to lead the carbon market, with 49% of registered projects, followed by India with 31% of projects, China with 6% and the rest of the world with 14%. To facilitate the analysis, the supply of CDM projects in this study has been divided into precisely these four blocks of countries.

China and India both form natural blocks, since they are too large in terms of physical size and economic growth to be included with the rest of the world and, as the figures and various economic analyses show, together with Latin America they are the two most important sources of potential CDM projects. The following figure ranks the developing countries according to the number of their registered CDM projects.

[10] At the Conference of Parties to the United Nations Framework Convention on Climate Change (COP 11) in Montreal in December 2005, Annex 1 countries agreed to fund the financial deficit of the Clean Development Mechanism's Executive Board by contributing around US$ 8,188,050.

FIGURE 23
NUMBER OF CDM PROJECTS REGISTERED UP TO AUGUST 2006



Source: United Nations Framework Convention on Climate Change (2006).

Latin America has been the largest supplier of CDM projects since the carbon market began. It was the pioneer region in "pre-Kyoto" pilot projects and went on to play a dominant role in project portfolios for the first carbon funds, such as those of the World Bank and the direct purchase fund of the Dutch Government's Certified Emission Reduction Unit Procurement Tender (CERUPT). In addition, the Andean Development Corporation (CAF) founded the Latin American Carbon Programme (PLAC) exclusively for the Latin American region. Latin America's role in the carbon market came about as the result of its Governments' openness to the development of the CDM and because they have relatively simple approval systems, as well as initiatives for promoting the CDM.

Although in theory China and India have the greatest potential for CDM projects owing to the size of their economies and their heavy use of highly carbon-intensive fuels like coal, their Governments were cautious when the market first started. After the Kyoto Protocol came into force they defined the regulatory and institutional framework for developing the CDM, which led to a plethora of applications for CDM projects. This began to legitimize the market, increasingly reflecting the real importance of these markets.

Ranking a country in the CDM market based on the number of its registered projects, India is the most important country, followed by Brazil, Mexico and China. Brazil and Mexico together represent 61% of registered projects in Latin America, which confirms that the major economies offer greater opportunities for supplying CDM projects.

Chile's great importance in the region lies mainly in its continuing investment-friendly environment stemming from a stable economy, an aggressive private sector and a favourable institutional framework. Honduras is important because of its capacity to supply hydroelectric projects eligible for the CDM and because of a set of conducive factors, including the

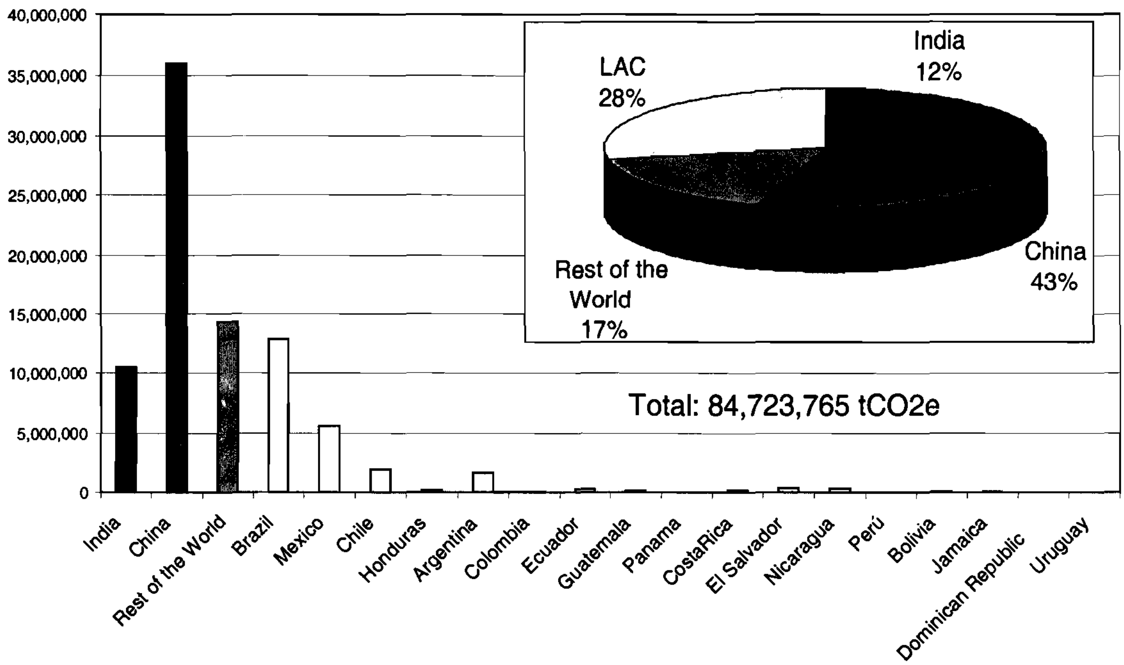
Government's openness to the CDM, the existence of a committed energy consortium and the support of Finnish development cooperation agencies for promoting the CDM.

In spite of their willingness, other countries' economic problems and current circumstances (such as the crisis in Argentina) prevent the development of more CDM projects. In several countries of the region there are also barriers that discourage the development of renewable energies and so block the development of CDM projects. This is discussed in more detail later in this study.

However, an analysis of the volume of emission reductions by region paints a different picture. The following figure shows that China has the greatest potential for emission reductions in registered projects. With only 15 projects, its annual capacity to generate CERs is 35,961,827 tons of carbon dioxide equivalent (tCO_2e), or 43% of the world volume of CERs. As explained later in this study, the reason is that China has registered enormous projects for decomposing HFC-23[11], a gas with high global warming potential, for which one ton of emission reductions is equivalent to 11,700 tons of CO_2.

The region's project portfolio is dominated by renewable energies which, while they do not contain as many emission reductions per project, have a much greater impact on sustainable development than do China and India's large-scale HFC-23 and N_2O decomposition projects for reducing greenhouse gases with high global warming potential.

FIGURE 24
ANNUAL VOLUME OF TCO_2E REDUCED BY REGION FROM REGISTERED CDM PROJECTS



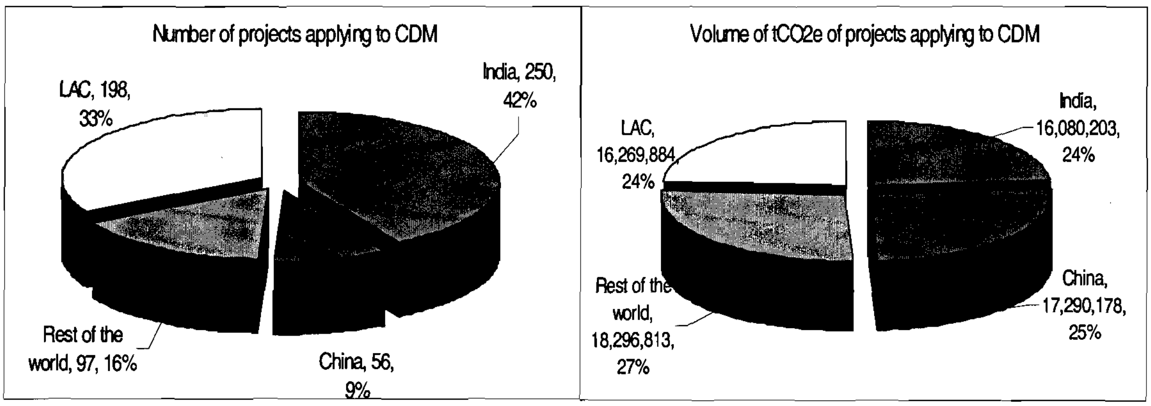
Source: ECLAC Natural Resources and Infrastructure Division, based on a working paper by Lorenzo Eguren using data from the UNEP Risø Centre on Energy, Climate and Sustainable Development (June 2006) and information from the United Nations Framework Convention on Climate Change (August 2006).

11 Trifluromethane. Around 98% of HFC-23 emissions are generated as a by-product from manufacturing the coolant HCFC-22 (chlorodifluoromethane), commonly used in air conditioning systems.

(C) Number and volume of projects in the region applying to the CDM

One way to make a medium term calculation of the CDM market's potential is to look at the number of projects that are applying to the mechanism but have not yet been registered. The region with the largest number of projects in the application phase is India, with 250 projects (accounting for 42% of all applications). Latin America accounts for 33% of applications, with 198 projects. China accounts for 9% of all projects applying for registration, and the rest of the world, 16%. As regards the volume of tCO_2e reductions represented by these projects, it is divided more or less equally between all the regions of the world, as the following figures show:

FIGURE 25
NUMBER AND VOLUME OF PROJECTS APPLYING TO THE CDM UP TO AUGUST 2006



Source: ECLAC Natural Resources and Infrastructure Division, based on a working paper by Lorenzo Eguren using data from the UNEP Risø Centre on Energy, Climate and Sustainable Development (June 2006) and information from the United Nations Framework Convention on Climate Change (August 2006).

The following table makes a more detailed breakdown of the above data. It is important to note that currently registered projects represent an annual reductions potential of 84,723,725 tCO_2e, whereas projects in the application phase represent only 67,937,078 tCO_2e (or 80% of the potential reductions registered up to now).

However, the number of projects applying for registration is nearly double the number of projects already registered (601 as compared with 259). This means that the largest projects have already registered and that smaller renewable energy projects are now applying for registration.

As already mentioned, a number of economic models[12] based on mitigation costs predict a demand for CERs of 200 million tons per year. As the above table shows, to date projects amounting to more than 152 million tCO_2e reduced per year have been identified as being in the application phase or registered by the CDM Executive Board.

Bearing in mind that many of the projects applying for registration will not be registered and that some registered projects will not be implemented, there are still opportunities for a large number of CDM projects which, at the very least, will need to represent annual reductions of more than 50 million tCO_2e in order to meet the predicted demand for CERs. This is particularly

[12] Economic models of Jotzo, Frank and Axel Michaelowa "Estimating the CDM market under the Bonn agreement" "Discussion Paper 145. Hamburg Institute of International Economics (HWWA) 2001 and of Rosenzweig, Richard and Rob Youngman. Looking forward from 2005: more surprises to come? *Natsource. 2005. in* "Greenhouse Gas Market 2005: The rubber hits the road" Editor: Robert Dornau. International Emission Trading Association (IETA). 2005. Page 9.

encouraging for the region, since the future portfolio of CDM projects will comprise a much larger number of projects as there will be fewer large-scale emission reduction projects (such as HFC-23 and N_2O decomposition projects). This should give greater impetus to renewable energies in this market.

Table 15
CDM PROJECTS SUBMITTED TO THE EXECUTIVE BOARD (AUGUST 2006)

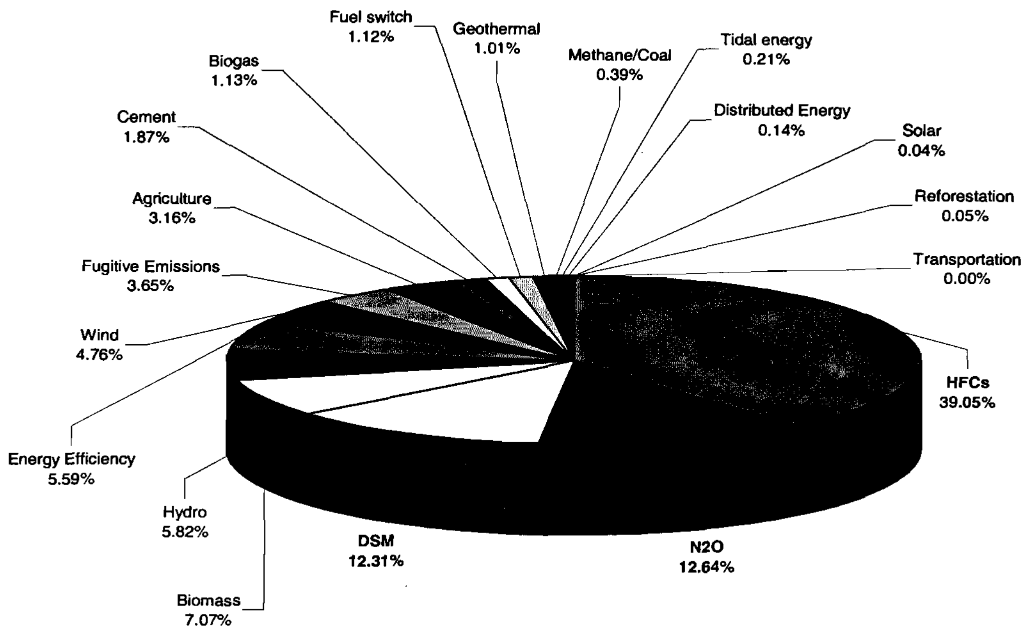
Region	*Number of projects*			*Volume of tCO2e*		
	Registered	**Under application**	**Total**	**Registered**	**Under application**	**Total**
Brazil	58	102	160	12 874 046	7 596 528	20 470 574
Mexico	20	34	54	5 628 639	1 673 864	7 302 503
Chile	13	10	23	1 985 122	1 734 682	3 719 805
Honduras	9	10	19	177 590	268 258	445 847
Guatemala	3	8	11	139 969	550 860	720 829
Ecuador	3	7	10	243 145	224 155	467 301
Argentina	5	4	9	1 695 094	1 884 141	3 579 234
Colombia	3	4	7	71 306	393 887	465 193
Peru	2	5	7	45 308	1 071 412	1 116 720
El Salvador	2	3	5	360 268	138 539	498 807
Panama	3	2	5	60 341	62 940	123 280
Bolivia	1	3	4	82 500	177 511	260 011
Costa Rica	2	2	4	162 431	48 767	211 198
Nicaragua	2	1	3	330 723	62 197	392 920
Uruguay	0	2	2	0	236 264	236 264
Dominican Republic	0	1	1	0	115 879	115 879
Jamaica	1	0	1	52 540	0	52 540
Total Latin America	*127*	*198*	*325*	*23 909 022*	*16 269 884*	*40 178 905*
China	15	56	71	35 961 827	17 290 178	53 252 006
India	80	250	330	10 519 289	16 080 203	26 599 493
Rest of the world	37	97	134	14 333 626	18 296 813	32 630 440
TOTAL	259	601	860	84 723	67 937 078	152 660 843

Source: ECLAC Natural Resources and Infrastructure Division, based on a working paper by Lorenzo Eguren using data from the UNEP Risø Centre on Energy, Climate and Sustainable Development (June 2006) and information from the United Nations Framework Convention on Climate Change (August 2006).

(D) Technologies used in the region's CDM projects

Taking into consideration all the projects submitted to the United Nations, including those that have been registered and those in the application phase, the most important sector in the region in terms of emission reductions is the destruction of methane from sanitary landfills (demand-side management, solid municipal waste), which represents 31% of all emission reductions.

FIGURE 26
ANNUAL VOLUME IN TONS OF CO_2 REDUCTIONS BY TYPE OF CDM PROJECT IN LATIN AMERICA AND THE CARIBBEAN



Source: ECLAC Natural Resources and Infrastructure Division, based on a working paper by Lorenzo Eguren and data from the UNEP Risø Centre on Energy, Climate and Sustainable Development (June 2006) and information from the United Nations Framework Convention on Climate Change (August 2006).

While there are only two HFC-23 projects, they represent 13% of the region's emission reductions. One project is in Mexico and has already been registered, whilst the other is in Argentina and is in the process of being registered. The N2O project is located in Brazil but represents 15% of Latin American emission reductions.

Agriculture projects, which consist mainly of capturing and destroying methane from pig farms, are distributed throughout Latin America, although they are most important in Mexico, Brazil and Chile. Biomass projects are dominated by Brazil and consist of energy generation and bagasse cogeneration projects. Hydroelectric projects are distributed throughout Latin America. There are fewer wind power projects (11). There are three geothermal projects located in Central America (Guatemala, El Salvador and Nicaragua) which range in size from 44MW to 66 MW, as the following table shows.

Table 16
CDM PROJECTS IN THE REGION, BY TYPE OF ACTIVITY

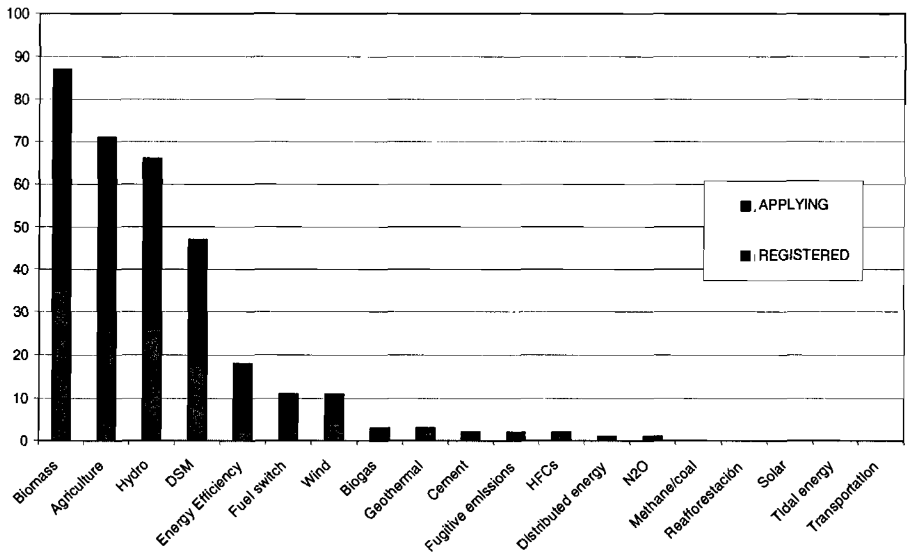
Type	Number of projects			Volume in tons of CO_2 equivalent per year		
	Registered	Under application	Total	Registered	Under application	Total
Biomass	34	53	87	1 483 179	2 868 848	4 352 028
Agriculture	33	38	71	2 790 360	1 677 851	4 468 210
Hydroenergy	26	40	66	1 286 000	2 843 397	4 129 396
Demand-side management	21	26	47	7 429 287	4 793 666	12 222 953
Energy efficiency	2	16	18	92 592	516 574	609 166
Wind power	4	7	11	412 602	500 105	912 706
Fossil fuel switch	2	9	11	28 507	492 364	520 871
Geothermal energy	2	1	3	457 246	99 251	556 497
Biogas	0	3	3	0	79 839	79 839
HFCs	1	1	2	3 747 645	1 434 196	5 181 841
Fugitive emissions	1	1	2	220 439	527 960	748 399
Cement	0	2	2	0	420 753	420 753
N_2O	1	0	1	5 961 165	0	5 961 165
Energy distribution	0	1	1	0	15 080	15 080
Transport	0	0	0	0	0	0
Solar energy	0	0	0	0	0	0
Reafforestation	0	0	0	0	0	0
Methane/ Coal	0	0	0	0	0	0
Tidal power	0	0	0	0	0	0
Total	**127**	**198**	**325**	**23 909 022**	**16 269 884**	**40 178 905**

Source: ECLAC Natural Resources and Infrastructure Division, based on a working paper by Lorenzo Eguren and data from the UNEP Risø Centre on Energy, Climate and Sustainable Development (June 2006) and information from the United Nations Framework Convention on Climate Change (August 2006).

A glance at the projects currently applying for registration shows that the region's potential lies in biomass projects (such as bagasse cogeneration or energy based on other types of biomass like rice husks), managing solid animal waste (for instance from animal confinement farms in the agricultural sector), hydroelectric projects and solid municipal waste projects. To a lesser extent there is potential for other activities, such as energy efficiency, fossil fuel switch and wind power generation projects.

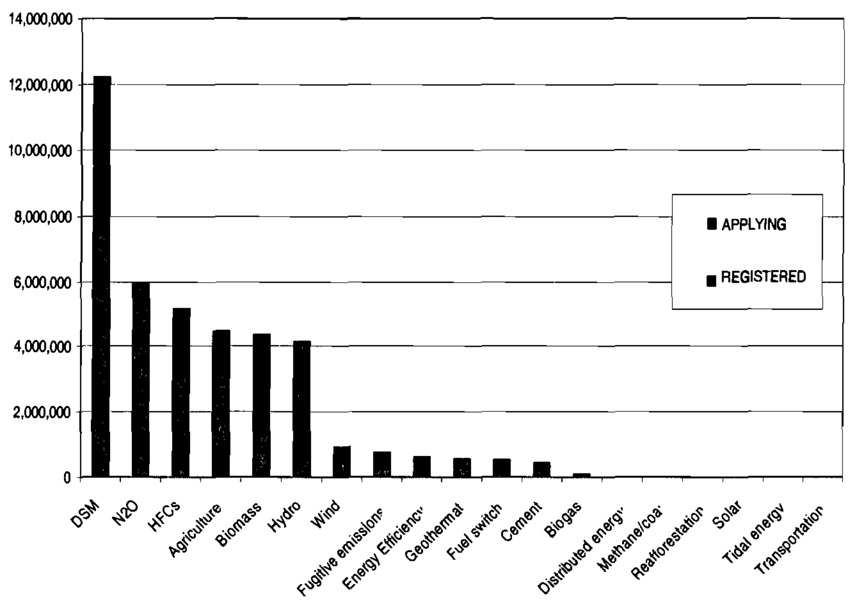
It is clear to see that, in Latin America, CDM projects will be dominated by renewable energies. A total of 127 projects have already been registered and 198 are in the application phase, although it is common knowledge that many more potential projects exist which have not yet been submitted (see the following figures).

FIGURE 27
NUMBER OF CDM PROJECTS REGISTERED AND APPLYING FOR REGISTRATION IN THE REGION, BY TYPE OF ACTIVITY



Source: ECLAC Natural Resources and Infrastructure Division, based on a working paper by Lorenzo Eguren using data from the UNEP Risø Centre on Energy, Climate and Sustainable Development (June 2006) and information from the United Nations Framework Convention on Climate Change (August 2006).

FIGURE 28
ANNUAL TONS OF CO_2 REDUCTIONS IN THE REGION'S CDM PROJECTS, BY TYPE OF ACTIVITY

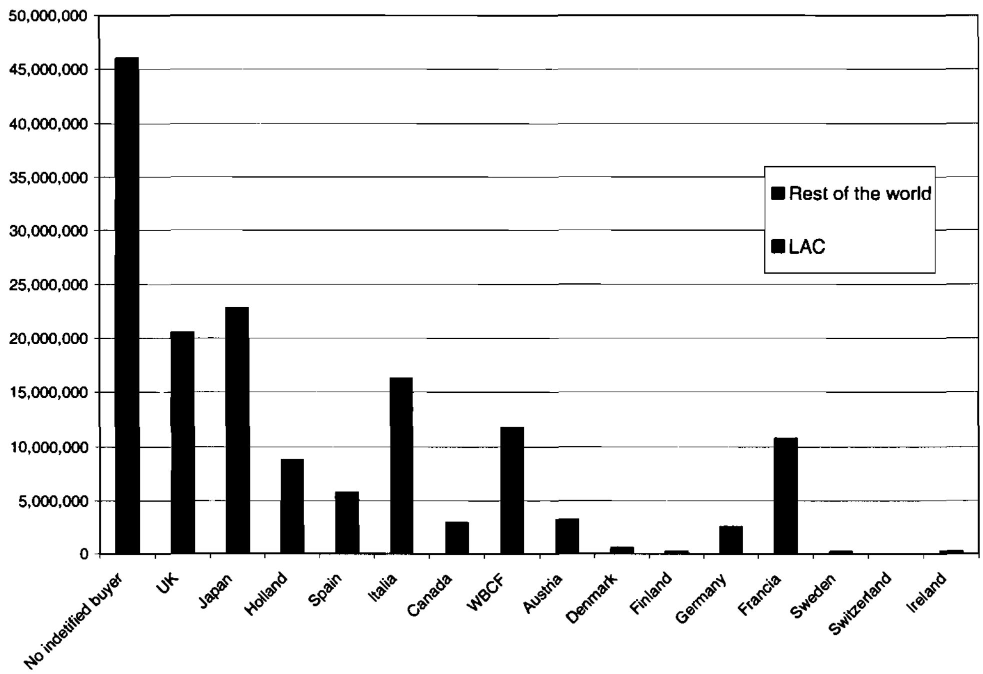


Source: ECLAC Natural Resources and Infrastructure Division, based on a working paper by Lorenzo Eguren using data from the UNEP Risø Centre on Energy, Climate and Sustainable Development (June 2006) and information from the United Nations Framework Convention on Climate Change (August 2006).

IV.3 Economics of carbon credits: purchasers and prices

A growing number of corporations, intermediaries and countries are actively seeking CERs in the CDM market. The growth in this activity stemmed from the entry into force of the Kyoto Protocol and the entry into operation of the European Union Emission Trading System (EU ETS). By assigning quotas to the industrial plants of private corporations, the EU ETS has sharpened their interest (especially large energy companies) in purchasing CERs in order to avoid heavy fines for non-compliance. The following figure shows the leading purchaser countries based on data in the Project Design Documents (PDD) at the CDM Executive Board meeting in August 2006.

FIGURE 29
ANNUAL EMISSION REDUCTIONS IN CDM PROJECTS PER PURCHASER



Source: ECLAC Natural Resources and Infrastructure Division, based on a working paper by Lorenzo Eguren using data from the UNEP Risø Centre on Energy, Climate and Sustainable Development (June 2006) and information from the United Nations Framework Convention on Climate Change (August 2006).

As the figure shows, a large number of Latin American and Caribbean projects do not specify which Annex 1 country their purchaser will be. It is plausible to assume that the great majority of these projects are designed for brokers to sell emission reductions directly on the EU ETS spot market or in Japan and Canada. This way of selling CERs without a forward sale contract (commonly known as an Emission Reduction Purchase Agreement or ERPA) is referred to as the "unilateral model" and is prompted by the wide divergence between the price of a fixed contract and the spot price.

In terms of emission reductions, Latin America does not have a large share in the portfolio of the leading purchasers. A likely reason for this is that large projects in China are willing to accept ERPA-type projects, whereas in Latin America projects are smaller and are more interested in unilateral contracts, and that Latin America's carbon market is more experienced than those of other regions.

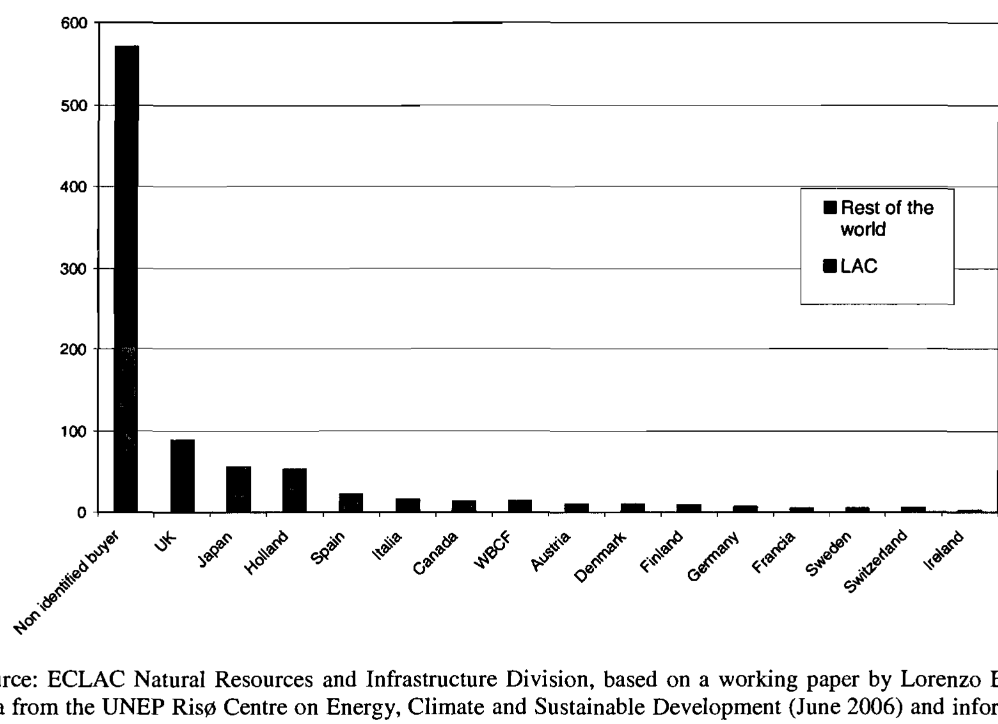
Japan is the foremost world purchaser, chiefly via private sector firms like Mitsubishi, TEPCO and J-Power. Japan's project portfolio is concentrated in Asia and in large-scale projects in countries like China. China's regulatory structure facilitates ERPA-type contracts, which is why Japan became interested in getting established in China.

The United Kingdom is the second largest purchaser and, even though it has a larger share in Latin America, it continues to be small compared with the United Kingdom's contracts elsewhere in the world. Even though the United Kingdom is under its Kyoto quota, the leading intermediaries in the CDM market are based there (Natsource, Ecosecurities, private investment funds, etc). Italy is the third largest purchaser and its purchases are concentrated in Asia, especially China, where it has a number of HFC23 projects. Italy buys via the World Bank, in public/private funds, or directly from firms like ENEL or ASJA. France is the fourth largest purchaser and its portfolio is concentrated in two large N2O projects, one in Brazil and the other in Korea. The purchaser of both is a French chemical company called Roída.

The Netherlands was the pioneer in the carbon market with government initiatives that started off by purchasing directly and later via intermediaries (mainly multilateral banks). Its portfolio is relatively evenly spread between Latin America and the rest of the world. Spain is also a major world purchaser and buys mainly via the World Bank, as well as directly from large corporations like Unión Fenosa and Endesa. Spain has a greater number of emission reductions in the rest of the world than it has in Latin America.

Based on the number of projects under a purchase agreement rather than on emission reductions, Latin America has a much larger share in the portfolios of these countries, but it also dramatically increases the importance of the unilateral model.

FIGURE 30
NUMBER OF CDM PROJECTS PER PURCHASER



Source: ECLAC Natural Resources and Infrastructure Division, based on a working paper by Lorenzo Eguren using data from the UNEP Risø Centre on Energy, Climate and Sustainable Development (June 2006) and information from the United Nations Framework Convention on Climate Change (August 2006).

World Bank funds (World Bank Carbon Finance – WBCF) are presented as though they were practically alone in Asia and do not appear to be very important. However, it is important to clarify that the World Bank buys from countries to order, meaning that some of its projects were treated as part of purchases by individual countries.

The same happens with other major funds. In 2005, the CD4CDM project[13] prepared a summary of all carbon funds. Carbon funds can be divided into funds managed by: (i) multilateral banks, (ii) Governments, and (iii) the private sector. As a whole, carbon funds dispose of a total of around US$ 2,224 million for purchasing CERs. The multilateral banks have the largest funds, with US$ 962 million, practically all concentrated in the World Bank; public funds represent US$ 343.75 million and private funds represent US$ 918 million (see the following table).

Table 17
LEADING CARBON FUNDS WORLDWIDE

Name of Fund	Size of Fund	Web pag
Funds manager by multilateral financial institutions		
World Bank - Prototype Carbon Fund	$180 million	www.prototypecarbonfund.org
World Bank - Community Develop-ment Carbon Fund	$128.6m million first tranche. Second tranche oponed late 2005.	www.carbon?nance.org/cdcf/home.cfm
World Bank - Biocarbon Fund	US $100 million expected but will start Operating at US$ 30million	www.biocarbonfund.org
Banco Mundial Netherlands CDM Fa-cility	$180m	www.carbon?nance.org/Nether-landsClean.htm
World Bank - Italian Carbon Fund	$80m	www.carbonfinace.org
World Bank -IFC Netherlands Carbon facility (INCaF)	44m euros	www.ifc.org/carbon?nance
World Bank - Netherlands European Car-bon Facility (NECaF)	10 millon tons of emisión reductions	www.ifc.org/carbon?nance
World Bank - Danish Carbon Fund (DCF)	US$35 million in the first portafolio of 5-7 projects	www.carbonfinace.org
World Bank - Spanish Carbon Fund	US$210 m	www.carbonfinace.org
MCCF (Multilateral Carbon Credit Fund)	Between 50 million and150 millions euros	www.ebrd.com/carbon?nance
CAF- Netherlands CDM Facility - PLAC	40m euros (10Mtons CO2eq)	http://www.caf.com/view/index.asp?ms=12
Government funds manager by Governments or local Institutions		
Austrian JI/CDM Programme	euros (11M 2004, 24M 2005, 36M 2006, 36M anuales 2007-2012)	www.ji-cdm-austria.at
KfW Carbon Fund	50m euros	www.kfw.de/carbonfund
EcoSecurities Standard Bank Carbon Facility	10m euros	www.essbcarbonfacility.com
Flemish Government JI / CDM Tender	70m euros	www.energiesparen.be
Belgian JI / CDM Tender	10m euros	www.klimaat.be/jicdmtender/
Finnish CDM / JI Pilot Pro-gramme	20m euros (10m bilateral / 10m en PCF and TGF)	www.global.?nland.?/english/projects/cdm
Rabobank-Dutch government CDM Facility	10 millon tons of CO_2 equivalent	www.rabobank.nl
Private funds		
Japan Carbon Finance,Ltd	$141.5 m	www.jcarbon.co.jp
European Carbon Fund	105m euros	www.europeancarbonfund.com
GG-CAP Greenhouse Gas Credit Aggregation Pool	98.6m euros	www.natsource.com
ICECAP	40-50 millions tons of CO_2 equivalent	www.icecapltd.com
Asia Carbon Fund	Euro 200 m	http://www.asiacarbon.com/asiaCarbonFund.htm
Trading Emissions PLC	US$200 m	www.tradingemissionsplc.com
IUCN Climate Fund	US$10million	www.iucn.org/

Source: Carbon market Update for CDM Host Countries. CD4CDM project. - UNEP Riso Centre and IETA, May and September 2005.

13 "Capacity Development for CDM", a four-year project implemented by the UNEP/Riso Centre.

At present, carbon funds, especially those managed by multilateral banks, find it fairly difficult to secure CDM projects. Their rigid prices and contracts (many of which are forward sale contracts/ERPA at a fixed price that is low compared with the spot price) prevent them from competing readily in the international carbon market.

Consulting firms which offer customized contracts for CER sellers (which range from totally unilateral models to fixed-price ERPA or a mixture of the two) provide very stiff competition to these funds.[14] In addition, these consulting firms have lists of private firms willing to pay higher prices than multilateral banks for ERPA. These firms' revenues comprise fixed consulting fees or commissions on the sale of CERs. Various private funds have found a way to be competitive as not only do they offer ERPA, they can also advance money to finance projects, which this makes them highly competitive because the vast majority of CDM projects suffer from financing problems.

Before the Kyoto Protocol and the EU ETS came into force in 2005, prices offered for a CER were extremely low owing to uncertainties in the carbon market. Transactions were confined mainly to forward sale contracts/ERPA, which are agreements to purchase a fixed amount of CER at a fixed price for a specified period of time. This market was controlled mainly by the World Bank, which purchases CER on behalf of Annex 1 countries and corporations and played a crucial market catalyst role.

The delivery risk, as well as the risk that the Kyoto Protocol would not come into force, kept CER prices very low (around US$ 3.5 per tCO_2e). After 2005, when the Kyoto Protocol and the EU ETS were into force, the risk of there being no market for emission reductions evaporated and the carbon market became a reality, which caused prices to rise and more purchasers to enter the market.

The price difference between ERPA and the spot market led increasing numbers of CDM projects to apply unilaterally for CDM registration, that is to say, without any prior commitment to sell CERs to an Annex 1 country or entity. These projects sought to secure higher prices, either by negotiating ERPA under better terms (since they are already registered and therefore run no risk of ineligibility for the CDM), or by selling CERs directly to the spot market after they have been produced.

As CERs can be exchanged for EAUs[15] (since they both serve to offset the emission of one ton of CO_2e), in theory they should cost the same amount. Historically however, the price of an EAU has averaged twice or three times more than in an ERPA, which makes it very attractive to use the unilateral model. Having said that, forward sale contracts/ERPA will continue to appeal to projects with financial constraints because credit purchases committed in advance can be used as collateral for a loan to finance the project, or by means of any other project finance arrangement. In addition, with ERPA, the purchaser pays the transaction costs for applying to the CDM.

At present the spot price of an emission allowance in the European Union Emission Trading System has become the reference price for the various agreements in the CDM market. In forward contracts/ERPA, the EAU is discounted to reflect the risks of registration, delivery and market uncertainties in the future. These uncertainties are determined by: (i) the lack of signals on the price of emission reductions after the year 2012 (this uncertainty restricts carbon finance to commitments to pay only up to 2012); (ii) the uncertainty of Russia and Ukraine's surplus emission allowances (dubbed "hot air") being sold and accepted in the market; and (iii) the

[14] The leading world consultancy firms include: 2E Carbon Access, AgCert, Ecoinvest, Ecoenergy, ECOsecurities, MGM International, Price Waterhouse Coopers and AhlCarbono.

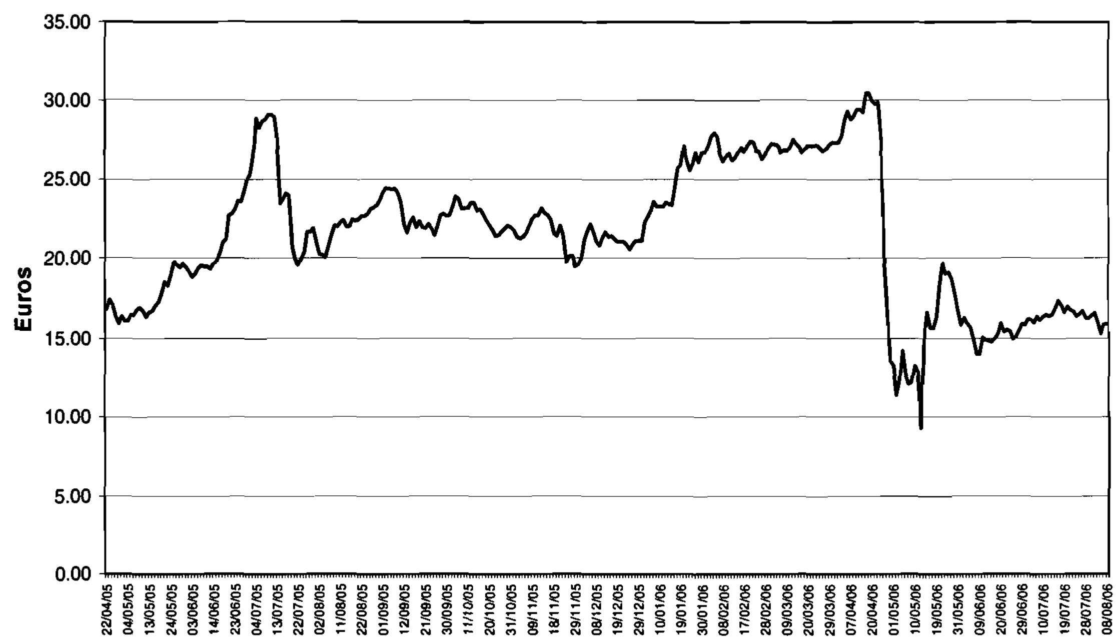
[15] EAU: Emission Allowance Unit (linked with the EU ETS).

uncertainty in the supply of emission reductions (Emission Reduction Unit – ERU) of Annex 1 countries, and the supply of CERs in China and India which they could sell on the market.

It is difficult to determine the long-term equilibrium price of EAU since the volumes traded have been very small, leading to great price volatility. In addition, uncertainty still hangs over plans for placing some European Union countries' quotas and the impact of oil prices on the EAU.

The following table shows the trend in the EAU price between April 2005 and August 2006. For a long period, the EAU price stayed above the 20 euro threshold, but in April 2006 it plunged to nine euros when it was announced that many European plants were under their assigned quota, creating expectations of lower prices. After that, prices recovered somewhat and since then they have remained at around 15 euros per EAU.

FIGURE 31
TREND IN THE PRICE OF AN EAU BETWEEN APRIL 2005 AND AUGUST 2006



Source: European Climate Exchange, 2006.

In forward sale contracts/ERPA, prices in recent transactions have ranged from 5 to 10 euros. Assuming a conservative price of US$ 7.5 (6 euros) per CER, Latin America's project portfolio – including registered projects and projects applying for registration – would total more than US$ 300 million per year (or more than US$ 1.5 billion for the five years of the first commitment period (2008-2012)).

IV.4 Barriers to the development of CDM projects in the region

Renewable CDM projects face not only barriers common to all renewable energy projects in the region, which have been identified clearly in a number of studies (like the ECLAC study for the Bonn International Conference for Renewable Energies in 2004), but also barriers arising specifically from CDM regulations, the main requirements of which are: (i) additionality; (ii) rigorous use of an approved methodology for establishing the baseline, calculating emission reductions and monitoring; (iii) a Host Country Letter of Approval for CDM projects; and (iv) projects may not, and must not, receive official development aid.

According to the additionality requirement, CDM projects must show, first, that they do not form part of the baseline (meaning the most probable future scenario which will be shaped by common practice and/or the economically most attractive options that face no major barriers) and, second, projects must show that they could not be implemented without the economic incentive of the CDM. This makes the emission reductions additional because they reduce emissions in the most probable future scenario, that is to say the baseline.

To demonstrate additionality, the CDM Executive Board has made available an "additionality tool". According to the tool, to determine a project's additionality proof must be given that the project is not economically viable, or that there are barriers to its implementation, and it must be explained how the CDM economic incentive contributes to the project's viability.

This means that it is highly unlikely for very profitable projects or ones that do not encounter greater barriers because they are part of common practice, or other projects included in government policies, to be approved by the CDM. Most projects for which there are entry barriers or economic problems for the development of renewable energies are eligible for the CDM. Once measures are adopted or circumstances arise that remove the barriers to renewable projects and make them viable, then they are no longer eligible to receive the economic incentive of the CDM.

Paradoxically, even though the future of the CDM in Latin America relies on renewable energy projects, initiatives to support their development could jeopardize their eligibility as CDM projects. In some cases, the CDM rules have created the perverse incentive of postponing government support for renewables in certain sectors in order to make CDM projects eligible.

To overcome this problem, at its 22nd session in 2005, the CDM Executive Board clarified the issue of how to incorporate national and sectoral policies and regulations into the baseline.

Only national or sectoral policies and regulations that give comparative advantages to more emission-intensive technologies over less intensive technologies (which were emitted prior to the adoption of the Kyoto Protocol in December 1997) can be taken into account in the baseline. If the said measures were implemented after Kyoto, then the baseline scenario should refer to a hypothetical situation without considering the measures.

Also, national or sectoral regulations that give comparative advantages to less emission-intensive technologies and fuels over more intensive ones (such as subsidies to promote renewable energies or finance energy efficiency programmes), which have been implemented since the Marrakech agreements were adopted in November 2001, do not need to be taken into account when developing the baseline (the baseline scenario should refer to a hypothetical situation without considering the said measures).

These recommendations avoid the perverse incentive of giving support measures to polluting projects and of measures to promote renewable energies being deliberately withheld to make them eligible for the CDM. However, the recommendations on the inclusion of national policies and regulations can be applied if there is convincing justification or evidence that lead to suspicions of perverse incentives. If circumstances exist that prove that the measures were taken for reasons other than the CDM, then the policies and regulations should be considered as part of the baseline.

So far 62 methodologies have been approved, including 30 large-scale, nine consolidated, 19 small-scale and three afforestation and reafforestation methodologies, together with one methodology for selected small-scale afforestation and reafforestation projects. Even though, as we saw in the analysis by project type, the methodologies encompass many areas in all types of project, including a wide variety of renewable energies, the process for approving methodologies has been exceedingly slow and it is still very difficult to successfully complete the formalities for the approval of a new methodology.

Existing methodologies do not always match the countries' distinctive characteristics and, in such cases, they severely hamper application or penalize potential emission reductions. The methodologies also impose limits on the size of projects. In the case of hydroelectric power plants, the most commonly used methodology for large-scale projects is known as "ACM0002", under which there is a limit on the surface area of the reservoir (4 watts per square metre). Even though exceeding this ratio would require large reservoirs, for which most Latin American projects for run-of-the-river hydroelectric power plants could qualify, including hydroelectric power plants of up to 200 MW, the European Union has imposed stricter rules than the methodology for approving a hydroelectric project. To be selected within the European market, any project in excess of 20MW must comply with the regulations of the World Commission on Dams, under which reservoirs must be higher than 15 metres and have a volume of more than 3 million cubic metres.

Even though it is possible to deviate from approved methodologies, sometimes the formalities are slow or approval is refused. Large sectors, such as transport and forestry, have been totally unable to access the CDM market, although methodologies for both these sectors were finally approved not long ago, albeit very restrictive ones. One of the most important renewable energy sectors that still have no approved methodologies is biofuels. Even though methodologies have been proposed for the use of bioethanol and biodiesel in transport vehicles, they have still not been approved, an issue which is discussed in more detail later in this chapter.

Another barrier that projects can come up against for qualifying for the CDM are problems with obtaining the Host Country Letter of Approval for CDM projects. The CDM rules have established that CDM projects must contribute to the sustainable development of the country where they are based. As this is a complex issue, the final say on whether or not projects contribute to the country's sustainable development was left up to project host countries. Luckily this formality is relatively simple in Latin America and most projects tend to obtain approval in less than two months.

However, in a few cases this does not happen, as in the Bolivarian Republic of Venezuela, which still has not appointed its Designated National Authority CDM. In other countries the problem with host country approval is that the environmental issue is managed on a sector basis, as in Peru, or on a regional basis, as in Argentina, which means that the host country letter of approval is granted only after multisectoral or multiregional committees have approved the project, which in some cases can significantly delay the process. Another factor that causes severe hold-ups in the letter of approval is the lack of resources in the Designated National Authority to dedicate a group of professionals to the matter and the lack of legal means or criteria for determining whether or not projects contribute to sustainable development, which makes evaluation highly subjective.

A final major barrier is the fact that, under CDM rules, projects receiving official development aid are ineligible for the CDM. This closes the door on many renewable energy projects whose development relies on international donations.

IV.5 Future commitments (post-2012) and their possible impact on the region

The latest Conference of Parties (COP11) to the United Nations Framework Convention on Climate Change in Montreal in December 2005 started to discuss the issue of future post-Kyoto reduction commitments.

At the conference it became clear that the Annex 1 countries[16] which had ratified the Kyoto Protocol were considering continuing with emission reduction targets after the end of the first commitment period (2008-2012). The discussion was also left open on whether developing countries with larger emissions (China, India, Brazil and Mexico) should be made subject to some voluntary form of commitment to reducing greenhouse gases in the future. At present there is no emissions limit for developing countries.

For the time being, China and India have not changed their position that no targets should be specified for countries which, like them, are not Annex 1 countries. Although South Korea has repeatedly hinted that it would acquire reduction commitments in the post-Kyoto period, in its report to the United Nations its only conclusion on the matter was that industrialized countries ought to lead the future commitment period.

According to data from the International Energy Agency, between 1990 and 2003 emissions from Annex 1 countries fell by 6.2%, while emissions from non-Annex 1 countries increased by 55% during the same period. China is already the second largest pollution emitter in the world and India the fifth.

The United States is still the world's foremost emitter and has given no signs of wishing to be part of Kyoto, claiming that this would affect the country's economic growth and saying that it would refuse to adopt future commitments unless commitments were also imposed on developing countries. However, the United States proposes other formulas such as targets for carbon emission intensity (the ratio of CO_2 emissions to gross domestic product).

Meanwhile there is general agreement that unless the developing countries take measures, the efforts being made by the developed countries, no matter how intensive, will not be enough to mitigate climate change. However, it is an exceedingly thorny issue to demand that developing countries accept emission restrictions when they still need to focus their efforts on achieving development and their per capita emissions are way below those of industrialized countries. For the time being, the greatest responsibility for climate change falls on the industrialized countries because they are most to blame for cumulative emissions to date.

Many developing countries consider that the targets for greenhouse gas emissions should be applied only when they achieve the same level of economic welfare as developed countries. This view is based on the principle of "common but differentiated responsibilities". It is the principle which the UNICCO applied for separating countries into two groups: Annex 1 countries (the most industrialized countries) and non-Annex 1 countries, which are developing countries that historically emitted less and have no imposed emission limits but which it is hoped will start to cooperate in mitigating climate change as their economies and emissions continue to grow.

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[16] Annex 1 of the Kyoto Protocol: this includes the most industrialized countries, which have been assigned emission limits based on their greater historical responsibility for cumulative emissions.

The task of defining national emission targets based on development parameters is highly complex and almost entirely political. However, a number of approaches have already been proposed and the negotiations will most likely to hinge on them. According to studies by Daniel Bodansky (2004)[17] and Axel Michaelowa (2005)[18] the main approaches are:

(A) Grandfathering

Grandfathering consists of allocating emission allowances according to emissions in a specified base year. The Kyoto Protocol used this system as a basis for allocating emission limit commitments to Annex 1 industrialized countries. This is the preferred system for countries with very high level per capita emissions in the base year. In fast-growing developing countries, grandfathering would make it much more difficult to comply with fixed emission targets, since their per capita emissions would also be growing very fast. However, partial grandfathering of historic emissions is an important dimension of most compromise proposals. Even though China was responsible for around 15% of total greenhouse gas emissions in 2000, its per capita emissions are still very low in comparison with industrialized countries. The same applies to Latin America and the majority of developing countries. Therefore many countries consider that it is over hasty to set emission reduction commitments immediately after 2012. Recently a proposal for allocating emission limits based on projected future emissions rather than on historical emissions has been introduced into the debate[19].

(B) Per capita allocation

Equal per capita allocation of greenhouse gases has been argued for by developing countries from the start of the climate negotiation process. As immediate per capita allocation would lead to an enormous shortfall in Annex 1 emissions budgets and a corresponding surplus in non-Annex 1 budgets, it is not suggested by any policy proposal currently on the table. Whereas this proposal is attractive to developing countries, carbon emission intensity proposals indexed to gross domestic product (GDP) (proposal from the United States) are preferred by countries with low population growth, such as Japan and other Annex 1 countries. Many proposals contain elements of per capita allocation at a future date, but the problem is to define how the transition process is to be managed. Some argue that there are natural factors influencing the amount of per capita emissions in the various countries, such as a colder climate or lower availability of renewable resources, which could lead to differences in emissions and they should therefore be considered when adjusting emission quotas.

(C) Contraction and convergence

The long-term trend in the climate regime will probably reflect the principle that greenhouse gas emissions should converge to a common per capita level. Achieving this target would involve two steps: (i) an emissions quota is specified in accordance with an agreed level of long-term reductions in greenhouse gases in the atmosphere (contraction); (ii) emission quotas are distributed among countries in such a way that per capita emission converge by an agreed date (convergence).

(D) Distribution based on cumulative emissions

Originally proposed by Brazil during the Kyoto Protocol negotiations in 1997, the "Brazilian proposal" called upon Annex 1 countries as a block to reduce their greenhouse gas

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[17] Bodansky, Daniel, Sophie Chou and Christie Jorge-Tresolini. International Climate Efforts Beyond 2012: a Survey of Approaches Pew Center on Global Climate Change. December 2004.

[18] Michaelowa, Axel; Tangen, Kristian and Henrik Hasselknippe "Issues and Options for the Post-2012 Climate Architecture – An Overview"_DOI 10.1007/s10784-004-3665-7. International Environmental Agreements (2005) 5:5–24_ Springer 2005.

[19] Tae Yong JUNG, ANCHA Srinivasan, Kentaro TAMURA, Tomonori SUDO, Rie WATANABE, Kunihiko SHIMADA "Asian Perspectives on Climate Regime Beyond 2012". Institute for Global Environmental Strategies. Hayama, Japan. 2005. Page 17.

emissions by 30% below 1990 levels by the year 2020, and set forth a methodology for allocating emission reduction burdens among countries based on their relative responsibility for the global temperature increase. The proposal also included a new Clean Development Fund (which later became the Clean Development Mechanism), to which developed countries would be required to contribute if they did not meet their emission target (at a rate of US$ 10 per tCO_2e), and which would be used primarily to fund clean development projects. Since Kyoto, the "Brazilian proposal" has come to refer to burden sharing based on historical responsibility for climate change.[20]

The inclusion of China, India, Mexico and Brazil in some type of commitment is still in doubt. Any alternative that is agreed upon could significantly affect the carbon market but it would not end it. Too much development and progress has already been made in the global emissions trading system for it to be swept aside in the future, especially since the European Union has undertaken to continue its Emission Trading System regardless of what happens in the future.

If, as seems likely, Japan and Canada agree to continue with emission targets, the United States would stand alone. This would not only leave the United States out of the multilateral model of incentives for replacing antiquated carbon-intensive technologies for many years ahead, it would also leave it outside the global mitigation system. This would prompt American private firms and some States to seek initiatives on an individual basis for aligning themselves with global commitments to enable them to join the global economy and be competitive. In the long term, then, it is likely that, in one way or another, the United States will align with other countries on the issue of climate change and emissions trading.

[20] Bodansky, Daniel, Sophie Chou and Christie Jorge-Tresolini. International Climate Efforts Beyond 2012: a Survey of Approaches Pew Center on Global Climate Change. December 2004. Page 22.

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Annex 1
Basic concepts and methodology for calculating total energy supply and "renewability fractions"

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, whereas sustainability is defined as an attribute of the way the energy source is used (ECLAC, 2003).

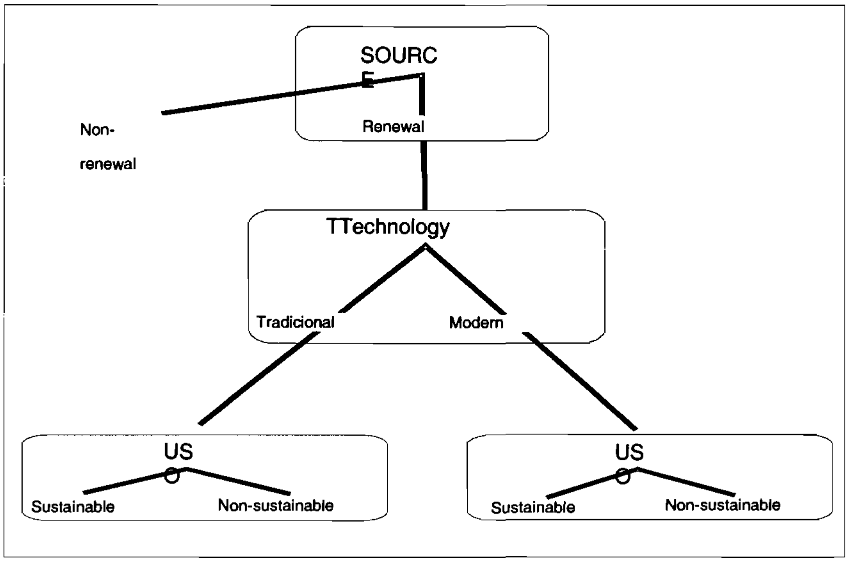
Although this document does not distinguish between "modern" and "traditional" biomass, these terms are common and reflect both the technology used to extract wood energy and its end use. Thus, energy from biomass used to heat households or prepare food is deemed to be a traditional use of energy (or technology), while biomass used to generate electricity and steam and to produce biofuels is deemed to be a modern use.

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

For example, fuelwood may be obtained from:

- Collecting dry branches or prunings.
- Felling trees at a rate higher than their natural regeneration rate.
- Felling trees and then replanting the felled species.

The conceptual framework adopted by ECLAC can therefore be presented graphically as follows:



Source: ECLAC document, Series LC/L 2132 (2004)

In the Scandinavian countries, for example, all fuelwood burned for household consumption can be described as sustainable, which is certainly not the case in developing countries, particularly in Latin America, where fuelwood biomass accounts for a major proportion of total energy supply (TES). As mentioned below, in some Central American countries, fuelwood contributes more than 40% of TES.

1. Methodology applied in the study

The Brasilia Platform on Renewable Energies sets out how to calculate the share of renewable sources as a proportion of total energy consumption. However, in this study it has been decided to calculate renewable sources as a proportion of total energy supply, because if the share were calculated as a proportion of consumption, the methodology would in fact fail to:

- Include transformation losses, or at least it would make it very difficult to calculate losses for sources emanating from a prior transformation process (such as charcoal produced from fuelwood) or from more than one transformation process (such as electrical power produced using diesel or fuel oil).
- Take into account losses of nearly 50% of the fuelwood used in charcoal production centres.
- Take into account losses in the systems of electricity transmission and transportation of derivatives (multi-purpose pipelines, trucks, etc.) and losses during electricity distribution or marketing of derivatives.

To calculate the shares of renewable sources, the preferred reference is the total energy supply (TES) measured as:

TES = total primary energy supply + total secondary energy supply – secondary energy production

This calculation method is more in keeping with the objectives set out in the Brasilia Platform because:

- It takes into account the pressure on a country's non-renewable resources, as well as the real share of renewable resources.
- It incorporates the entire physical flow of the supply system.
- It provides a more realistic method of quantifying the share for countries that import derivatives.
- It takes into account the pressure on the resources of exporting countries, since the pressure exerted by exports on primary energy production is included in the equation for calculating total supply.

As with any form of energy accounting, there is a series of conventions to be followed. In order to complete the supply equation, where necessary, for countries trading electrical power, the trade balance and the corresponding supply variations would also need to be taken into account.

This study therefore adopts the convention that, if the balance is positive (where imports exceed exports), the source is deemed to cause no environmental impact on the importing country. In order to avoid fictitiously inflating the renewable energy shares in the country under study, this balance is added to the other sources. Otherwise the energy balance of each transformation centre and the origin of the electricity output would need to be analysed. For example, 100% of the electricity Paraguay exports is hydroelectric, so it would be appropriate to assign the balance to that source. In cases where thermal power is exported, the balance is assigned proportionately to each fuel used in power generation. This would avoid distorting the share of the different renewable and fossil sources.

2. Proposed model

Since world energy statistics still make no distinction between the renewable and non-renewable portions of biomass, it is very difficult for a country to estimate how much of the energy available for supply and consumption can be truly considered renewable, particularly when considering the "sustainability" of the fuelwood biomass.

Brazil's Ministry of Mines and Energy has put forward a model based on sectoral consumption figures in the National Energy Balance Sheet (BEN) and information from the Brazilian Geographical and Statistical Institute (IBGE). Based on these energy consumption statistics, *"renewability fractions"* were assigned to each fuelwood consumption sector or subsector for the year 2002. According to this method, the percentages of renewable fuelwood used in the various sectors of application in Brazil were as follows:

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

In this study, the percentages were initially used as reference points for separating "sustainable" from "non-sustainable" fuelwood biomass. The aim of this first approach was to focus discussion on a "minimum methodology" for the countries of Latin America, taking into account specific local conditions. In keeping with this methodology, the term biomass "*fractions of sustainability*" will be used from now on.

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 the Latin American Energy Organization (OLADE).
- National sector information (data from national bodies responsible for keeping statistics for various sectors, such as forestry resources, industry and others).

The greater fuelwood's share of the country's energy supply, the more important it is to accurately calculate these "sustainability fractions" (in terms of "policy" analysis of the information). So, the figures for the Central American countries and Haiti, for example, whose energy structures depend heavily on fuelwood, will be those most affected by how accurately "sustainable biomass" is calculated. Since this is basically a fuelwood issue, it could be referred to as "sustainable wood energy".

For a rigorous analysis, Brazil's proposed methodology should therefore be used, adapting it to the specific conditions of, and information available for, the different countries in the region. The methodology should be applied 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 the current study.

3. Renewable energy categories

Based on the above information and categories, this study proposes to quantify how much the various renewable energy categories contribute to the total energy supply of each country in the region. The renewable sources considered were:

- Hydroenergy (large- and small-scale) (100% renewable).
- Geothermal energy (100% renewable).
- Sustainable wood energy, the portion of sustainable fuelwood biomass used for residential, industrial and agricultural energy and charcoal (100% renewable).
- Non-wood related sustainable bioenergy, such as agrofuels (cane products and other biomass residues) and municipal by-products (organic waste) (100% renewable).
- Other renewable technologies (using wind and solar energy) (100% renewable).

After removing the renewable energy category, this should leave the non-sustainable biomass or wood energy portion, alongside hydrocarbons, nuclear energy and coal. This would be the fuelwood portion stemming from deforestation (expansion of the agricultural frontier, illegal logging), which is therefore non-sustainable.