Chapter II:
Key Options for Reducing Energy-Related CO_2 Emissions in LAC. Lessons for CDM implementation

According the hypothesis for *Chapter II and III*, a significant potential for CC mitigation (and CDM projects) could be identified in LAC during the next two decades, and this potential is mainly related to the regional options to encourage sustainable energy and enhancing sinks.

The CC mitigation potential is different from CDM potential, due to several provisions in CDM design, such as additionatity issues, the conditions for including LULUCF activities under CDM, the cost associated to the CDM project cycle, among others. However, studying CC mitigation potential for LAC provides a general reference for defining a range of possibilities and options for implementing CDM projects.

Rather than offering a detailed quantification of CC mitigation potential in the region, this study would focus on key options for CC mitigation in sustainable energy and sink activities in LAC, and provides a general picture of the relative potential of LAC subregions/countries in both areas.

Taking into consideration the analysis carried out in *Chapter I* on the required integrated approach when implementing CC response strategies, this chapter would emphasise, whenever possible, those CC mitigation options which greater potential for contributing to sustainable development in LAC, considering the main socio-economic and environmental priorities of this region.

Chapter II refers to the regional options for reducing energy-related CO_2 by adopting sustainable energy patterns in LAC. This analysis especially emphasises sustainable energy options related to:

- More efficient use of energy.
- Increase reliance on renewable energy sources.

The definition of *sustainable energy* has been taken from *the World Energy Assessment 2000*, and refers to energy produced and used in ways that support human development over the long term, in all its social, economic and environmental dimensions. Therefore, this term does not refer simply to a continuing supply of energy, but to the production and use of energy resources in ways that promote –or at least are compatible with- long-term human well being and ecological balance *(UNDP-DESA-WEC, 2000: 3).*

The analysis of trends in energy-related CO_2 emissions and key mitigation options, mainly related to energy efficiency and promotion of renewable energy sources in LAC, is divided into five parts:

- *Trends in energy-related CO_2 emissions in LAC:* Past (1970-99) and future (1999-2015) trends;

- *Implicit energy patterns*[1] *in energy-related CO_2 trends and key mitigation options* in LAC;
- *Two alternative scenarios to the OLADE projections for energy-related CO_2 emissions*, with the objective of calculating potential CO_2 emission reductions;
- An *illustrative exercise regarding LAC potential for reducing energy-related CO_2 emissions and human development.*
- *A statistical exercise that compares two Indexes: Index A: Commercial Energy Coverage (1997), as a gross indicator of energy requirements in the region; and Index B: Total energy intensity (1997-98), as a gross indicator of the relative attractiveness for investments in sustainable energy.*

Whenever possible, statistical information is presented for the LAC subregions, and using official data sources, as OLADE (2001). Other bibliographical sources (such as IEA 2000, EIA 2000 and others) are also consulted for reference.

2.1. Trends in Energy-Related CO_2 Emissions in LAC

Energy-related CO_2 emissions in LAC increased by 3.7 per year in 1970-1999, and are expected to grow by 5.4% per year during 1999-2015, according to OLADE database. IEA projections, however, estimate that CO_2 emissions in LAC would grow by 3.1% per year in 1997-2020 *(IEA, 2000: 405).*

According to OLADE projections, regional emissions of CO_2 per capita are expected to increase for all of the sub-regions, especially in Brazil, Central America, the Andean Zone and the Southern Cone.

In most of the subregions, this trend would tend to rise the carbon intensity with respect to total energy supply, GDP, and electricity generation. Table 2.1 figures illustrate the increasing trend in energy-related CO_2 emissions in 2000-2015 in LAC.

Table 2.1
A: CO_2 emissions per capita (tonnes)

Subregions	2000	2005	2010	2015	Annual growth rate (%) 2000-2015
Mexico	6.26	7.08	7.82	8.74	2.25
Central America	0.84	1.13	1.33	1.63	4.52
Caribbean	4.32	5.94	6.49	7.21	3.47
Brazil	1.91	2.61	3.29	3.91	4.89
Andean Zone	6.25	7.69	9.68	11.94	4.41

[1] Energy patterns implicit in energy-related CO_2 emissions refer to: 1) Trends in energy intensity; and 2) Role of fossil fuels.

Southern Cone	7.93	11.49	13.13	14.68	4.19

B: Annual growth rate of CO_2 emissions/total energy supply; CO_2 emissions/GDP; and CO_2 emissions/electricity generation in 2000-2015 (%)

Subregions	**CO_2 Emissions/Total Energy Supply**	**CO_2 Emissions/GDP**	**CO_2 Emissions/ Electricity**
Mexico	1.15	-0.30	-1.78
Central America	1.03	3.39	4.34
Caribbean	2.51	2.12	2.98
Brazil	0.69	0.82	5.45
Andean Zone	0.82	1.28	2.95
Southern Cone	0.91	1.08	2.89

Source: Based on *OLADE (2001).*

During 1970-1999 LAC showed the greatest decline in the coefficient of CO_2 per energy unit, particularly during 1970-1985. The energy sector of LAC had the lowest specific emissions in the world in 1997, with 0.597 tons of C/toe. This figure, equivalent to 83% of the world average, is explained by the relatively high share of hydroelectricity and natural gas in the energy balance of the region, and the low share of coal *(see Suárez, 2000).* However, during 1999-2015, CO_2 emissions per energy unit are expected to grow in all the subregions, particularly in the Caribbean and Mexico. CO_2 emissions / GDP would also increase considerably in LAC, particularly in Central America in 2000-2015.

In the Mexican case, CO_2 emissions / total energy supply would increase by 1.2% a year during 2000-2015. However, CO_2 emissions / GDP and CO_2 emissions / electricity generation tend to decrease in the same period, in contrast to the projected trends of these indicators for the rest of the LAC subregions. This situation could be explained by expected structural changes in the Mexican economy, leading to a combination of rapid GDP growth and increasing use of natural gas in electricity generation.

CO_2 emissions / electricity generation would considerably increase in almost all subregions, except for Mexico. Brazil and Central America would register the highest increase in this indicator. This growing trend can be explained by the projected growth in thermal generation in many LAC countries during the next two decades.

The main trends in two key sectors (industry and transportation) are briefly presented in this section, only with the purpose of providing illustrative sectoral information[2]. Industry and transportation accounted for 33% and 47%, respectively of CO_2 emissions related to final energy consumption in LAC in 1997 (IEA, 2000: 405).

[2] It was not possible to carry out a comprehensive sectoral study due to lack of comparable figures for energy-related-CO_2 emissions in the OLADE database for the period 1999-2015.

Concerning the main trends in energy-related CO_2 emissions in the *industrial sector* of LAC, Table 2.2 reveals that this indicator increased by 2.7% a year, as average, in this region during 1970-1999. The general trend of growing emissions was particularly intensive in Brazil (3.6%), the Andean Zone (3.5%), and Central America (3.4%); while the corresponding average rate for the Southern Cone was less than 1% a year. Only Mexico and Brazil accounted for 51% of the regional energy-related CO_2 emissions in 1999.

Table 2.2
Energy-related CO_2 emissions in industry, 1970-1999 and 1999-2015 projections (Gg)

SUBREGIONS	1970	1999	Annual growth rate (%) 1970-99	Annual growth rate (%) 1999-2015 (*)
Andean Zone	18627.57	50641.69	3.51	5.66
Caribbean	12206.72	18194.81	1.39	1.30
Central America	1979.92	5146.29	3.35	2.91
Southern Cone	22330.12	28379.98	0.83	3.39
Mexico	24369.92	56538.98	2.94	7.61
Brazil	17752.67	49741.82	3.62	5.38
Latin America & Caribbean (**)	97266.92	208643.6	2.67	4.84

Note:
(*) This information for the period 1999-2015 was taken in relative terms (growth rates), only for general reference, due to lack of consistency between historical data and projections in the OLADE series.
(**) IEA projections show a different trend for LAC industry, with growth rates of 3.4% per year in 1971-97 and 2.4% per year in 1997-2000 *(IEA, 2000: 405)*

Sources: Based on *OLADE (2001).*

For the period 1999-2015, energy-related CO_2 emissions are expected to increase at a faster average rate for LAC (4.8% a year), with Mexico (7.6%), the Andean Zone (5.7%) and Brazil (5.4%) as the leaders of this tendency.

In *transportation*, energy-related CO_2 emissions increased by 4% a year, as average, in LAC during 1970-99. Most of the increase took place during the 1970s, with an emerging recovery during the 1990s, particularly in Central America, the Southern Cone and Brazil (see Table 2.3). According to IEA projections, CO_2 emissions of transportation sector would increase by 3.3% per year in 1997-2020 (3.8% per year in 1971-97) *(IEA, 2000: 405).*

Table 2.3
Energy-related CO_2 emissions in the transportation sector of LAC. Average growth rate during the 1970s, 1980s, and 1990s (%)

SUBREGIONS	1999 (Gg)	Annual growth rate (%) 1970-80	Annual growth rate (%) 1980-90	Annual growth rate (%) 1990-99	Annual growth rate (%) 1970-99
Andean Zone	80385.78	7.83	1.49	2.48	**3.94**
Caribbean	16840.83	3.78	-0.23	2.26	**1.91**
Central America	16903.46	5.69	2.49	7.86	**5.24**
Southern Cone	71482.89	2.68	0.31	5.48	**2.71**
Mexico	114685.7	9.17	2.61	2.23	**4.71**
Brazil	143139	7.10	2.20	4.37	**4.54**
Latin America & Caribbean	443437.6	6.62	1.78	3.60	**4.00**

Sources: Based on *OLADE (2001).*

The previous analysis of regional and subregional trends in energy-related CO_2 for 1999-2015 shows the considerable projected increase of this indicator, well above historical tendency for 1970-99, according to OLADE database.

This rapid growth in CO_2 emissions would be a common trend for all LAC subregions. Considering that these trends do not assume the adoption of CC mitigation policies and measures in the energy sector, those tendencies reveal a significant potential for CC mitigation options concerning sustainable energy in LAC. Taking into consideration the eligibility criteria for CDM projects, and other provisions such as additionality issues, and the real demand for certified emission reductions, part of this potential could be covered by CDM project activities.

After presenting the general and subregional trends in energy-related CO_2 emissions, it is worth identifying the main energy patterns implicit in those emission trends, as a condition to examine key mitigation options in the energy sector.

2.2. Implicit Energy Patterns in Energy-Related CO_2 Trends. Key Mitigation Options

The analysis of the implicit energy patterns in energy-related CO_2 emissions includes a review of general trends in energy intensity, as a reference to identify options for increasing energy efficiency. It also includes a general review of the composition of energy balance, as a reference for identifying options for promoting the use of renewable energy sources.

2.2.1. Trends in Energy Intensity and Options for Increasing Energy Efficiency

Primary energy demand in Latin America grew 2.3% a year over the past 20 years, with some emerging economies as the main contributors to this trend[3]. Commercial primary energy use increased by 3.6% per year, as average, during 1970-98 in LAC. This region accounted for 4.3% of world commercial energy demand in 1998 (see *UNDP-DESA-WEC, 2000: 33 and 195).*

Following the basic trends of the last decades, final energy consumption per capita is expected to notably increase in all LAC sub-regions during 2000-2015. The most rapid growth of this indicator would take place in Mexico and the Southern Cone (3.2% a year each), according to OLADE projections (see Table 2.4).

Table 2.4
Final energy consumption per capita (boe)

Subregions	**2000**	**2005**	**2010**	**2015**	**Annual growth rate (%) 2000-2015**
Mexico	11.07	12.94	15.23	17.85	3.24
Central America	4.44	4.84	5.27	5.78	1.77
Caribbean	8.93	10.11	11.72	13.9	2.99
Brazil	7.93	8.92	10.27	12.02	2.81
Andean Zone	14.8	17.12	19.81	23.00	2.98
Southern Cone	18.97	22.15	25.98	30.32	3.18

Note:
boe = barrels oil equivalent.

Source: Based on *OLADE (2001).*

According to IEA projections, total final energy consumption in LAC is expected to grow by 3.1% per year in 1997-2000 (4.1% per year in 1971-97)[4] *(IEA, 2000: 106-107 & 402-403).*

Concerning the potential for energy efficiency, it is worth noting that during 2000-2015, energy intensity would increase in Mexico, Central America, and the Caribbean. The Andean Zone and

[3] In 1997 only Argentina, Brazil, Mexico and Venezuela used 85% of the region's primary energy.
[4] These IEA projections assume an economic growth of 3.2% per year and a population growth of 1.3% for LAC in 1997-2000 *(IEA, 2000: 352-353).*

particularly Brazil would register reductions in this indicator, according to OLADE projections (see Table 2.5).

Table 2.5
Energy Intensity in LAC (boe/10^3 US dollars)

Subregions	**2000**	**2005**	**2010**	**2015**	**Annual growth rate (%) 2000-2015**
Mexico	3.16	3.29	3.41	3.49	0.66
Central America	3.78	3.86	4.01	4.16	0.64
Caribbean	7.05	7.59	8.19	9.00	1.64
Brazil	2.89	2.32	2.32	2.39	-1.26
Andean Zone	8.67	8.71	8.60	8.53	-0.11
Southern Cone	3.81	3.84	3.87	3.88	0.12

Note:
boe = barrels oil equivalent.

Source: Based on *OLADE (2001).*

At the end of this period, Brazil, followed by Mexico and the Southern Cone would show the least energy intensive economies in the region. As noted in Chapter I, these are precisely the three subregions in better position to face the socio-economic priorities and climate change mitigation challenges (see Table 1.2 in Chapter I). The Caribbean, followed by the Andean Zone and Central America, would register the highest levels of energy intensity in the region, with the concomitant adverse implications in terms of growing CO_2 emissions.

In general terms, LAC energy consumption in the next two decades will continue being driven by industrialisation, urbanisation, increasing road transportation, and increasing personal incomes. These patterns tend to increase future emissions of energy-related CO_2 emissions, particularly in a context of growing energy intensity in most of the LAC subregions. Wide income disparities in LAC, referred to in Chapter I, are also reflected in energy consumption patterns within and among countries.

In Latin American countries, industry consumed about 36% of final energy use in 1997; and regional energy intensity has increased, partially because of the deterioration of energy efficiency in heavy industries. In these conditions, substantial potential for energy efficiency improvement is reported *(see Table 2.6).*

Table 2.6
Potential energy savings in energy intensive industries in Latin America (%).

Subsectors	***Short term/small investments***	***Long term / medium size investments***
Steel	5-7	5-13
Aluminium	2-4	10-15
Oil	7-12	15-25
Fertiliser	2-5	20-25
Glass	10-12	15-20
Construction	10-15	15-20
Cement	10-20	10-30
Pulp and Paper	10-15	10-16
Food	8-18	12-85
Textile	12-15	15-17

Source: Videla (1994: 348-349)

Four subsectors (cement; iron and steel; chemicals; food and beverages) consume 60% of industrial energy in Latin America; with iron and steel alone accounting for 23% of energy used by industrial sector. According to specialised studies, better management of blast furnaces, the injection of gases and improved processes could reduce energy demand by 10-28% *(UNDP-DESA-WEC, 2000: 195).* This CC mitigation effort would contribute to reduce energy intensity in heavy industries in the region.

The *World Energy Assessment 2000* emphasises that the significant potential of combined heat and power (cogeneration) is marginally exploited in most Latin American countries. This potential is great in sectors such as paper and pulp, chemicals, and the alcohol-sugar industry, where industrial residues can be used to generate electricity.

In recent years many manufacturers in industrialised nations have moved energy intensive industries to LAC often to take advantage of cheap labour, less stringent environmental regulation, and lower overhead and transportation costs. This trend could be reinforced within the Free Trade Area for the Americas (FTAA), taking into consideration the objectives of investment liberalisation, with no restrictions for the investors, prevailing under this initiative, as explained in Chapter I *(see also TAM, 2001).*

In the *residential sector,* as mentioned in Chapter I, around 60% of regional population depends on firewood and charcoal as domestic fuel; and in several countries – particularly in Central America - traditional fuels based on biomass account for more than 40% of their national energy balances: Nicaragua (43%), Paraguay (48%), Honduras (50%), Guatemala (59%) and Haiti (81%) *(UNDP, 2000).*

In the residential sector, nearly half of energy used for cooking is from firewood[5]; however, the use of biomass (firewood and charcoal) is declining, and the use of liquefied petroleum gas and natural gas is growing. As these commercial fuels are more efficient, per capita energy consumption would be 20% lower by 2020 in this sector, according to the *World Energy Assessment 2000.* In lower-income regions, energy consumption by households shifts from traditional to commercial fuels, when disposable income increases *(UNDP-DESA-WEC, 2000: 180-181).* CC mitigation efforts in this subsector would require a combination of options including more efficient technologies for using traditional fuels, and greater access to less pollutant commercial fuels.

Expected use of non-commercial energy – particularly firewood, charcoal, crop residues and animal wastes – in LAC would increase by 0.5% per year in 1997-2000, while conventional energy consumption would increase by 3.1% per year in that period. Therefore, the share of non-commercial energy in total energy consumption of the region would decline from 15% in 1997 to 9% in 2020 *(IEA, 2000: 59).*

Household appliances, cookers, and water heaters have become more energy efficient in higher-income regions of LAC. But the rapid acquisition of household devices has far outpaced the impact of greater efficiency. Specific savings in electricity use by appliances range from 20% to 40% over the next 10-20 years for several Latin American countries *(UNDP-DESA-WEC, 2000: 195).*

Chapter I also refers to the high number of low-income people with not access to electricity services in LAC (30% of LAC population): 66% in Haiti; 49% in Bolivia; 49% in Nicaragua; 46% in Honduras; 36% in Guatemala; 28% in Peru; 27% in El Salvador; 26% in Panama; 22% in Ecuador; 19% in Colombia; 18% in Guyana; 18% in Jamaica; 17% in Paraguay; and 16% in Dominican Republic *(see OLADE, 2001).* Per capita electricity consumption for Central and South America[6] is roughly 12% of that of the USA *(EIA, 2000: 122).* The adoption of sustainable energy policies and measures to gradually eliminate this deficit should be one of the most relevant challenges in the socio-economic agenda of the region for the next decades.

Regional power-capacity requirements in 1997-2020 amount to 282 GW of additional capacity (18% of total requirements in developing countries); and the estimated investment cost of new power plants over that period, excluding the costs of new transmission and distribution lines, is nearly 363 billion dollars – at 2000 prices. This would mean annual investments of around 16 billion dollars during 1997-2000 *(IEA, 2000: 106-107 & 402-403).*

Under the ongoing process of privatisation in LAC, foreign investors channelled more than 45 billion dollars into LAC electricity investments between 1990 and 1997, resulting from investments in privatised electricity projects in the region. Brazil has been the largest target of the

[5] Data cover only Argentina, Brazil, Mexico and Venezuela.
[6] Includes the Andean Zone, the Southern Cone and Brazil.

US investment in South America, followed by Argentina *(see EIA, 2000: 120-121).* However, it is worth noting that the quantitative limits of this investment flow are determined to a great extent by the number of assets to be privatised, which is decreasing rapidly as result of the privatisation process.

Transportation accounted for 38% of final energy consumption in LAC in 1997; absorbing a rising share of energy use, particularly in higher-income countries of LAC *(see IEA, 2000: 402-405).*

In Central and South America[7], the number of vehicles per thousand persons would grow from 86 vehicles in 1997 to 194 vehicles in 2020 *(EIA, 2000: 143).* Many cars and light trucks sold in the region have become less fuel intensive; but increased urbanisation and traffic congestion and reduced occupancy have offset many of the improvements in vehicle technology. About two thirds of Latin America's transport energy demand is concentrated in Brazil and Mexico, where road transportation accounts for 90% of the sector's energy consumption. Subway systems have not grown at the same rate as passenger demand for travel in Latin America's major cities, the exception being Curitiva, Brazil *(UNDP-DESA-WEC, 2000: 1997-198).*

Taking into account the emission trends of the last 30 years and the growing foreseeable tendencies of transportation in the context of globalisation, investments to increase energy efficiency in this sector and to ensure an equitable access to these services represent important challenges for sustainable energy development in LAC.

In general, there is a significant potential in LAC for CC mitigation options that combine the required improvement in sustainable energy coverage and increasing energy efficiency. An index of energy efficiency and sustainable energy coverage, calculated for 65 countries in 1998 reveals that the effort of LAC in these directions only represents 68.6% of the existing potential, according to world standards. The corresponding figures for developed and developing countries are 88.0% and 59.6%, respectively *(see Pichs, 1998).*

When the various subregions are compared, the Caribbean, the Andean Zone and Central America show the greatest relative potential to reduce energy intensity. Taken the Brazilian economy in 2015 as reference, the Caribbean and the Andean Zone would be almost four-fold each more energy intensive than Brazil, and Central America would be 74% more energy intensive than Brazil. At the same time, the Caribbean, Central America and the Andean Zone concentrate the greatest deficits of sustainable energy coverage in the region, and are affected by financial and technological restrictions to address CC mitigation. For these reasons, these subregions would be interested in attracting CDM projects.

In terms of attractiveness for CDM projects in energy efficiency, Central America, the Caribbean and the Andean Zone could be the most attractive subregions in LAC due to the lower marginal abatement costs associated to their relatively lower level of economic development *(see Chapter I, Table 1.2).* However, it would be important to also consider investment risks and other

[7] Includes the Andean Zone, the Southern Cone and Brazil.

potential costs associated to the CDM project cycle (monitoring costs, for instance) that can affect initial considerations regarding relative attractiveness for CDM project activities.

The projected increase in energy intensity in most of LAC subregions is combined with a high dependency on fossil fuels in the region during the next two decades.

2.2.2. Composition of Energy Balance and Potential for Increasing the Use of Renewable Energy Sources[8]

Considering that one of the main features of LAC energy sector is its high dependence on fossil fuels; another important option in terms of sustainable energy for LAC is realising the potential to increase the reliance on renewable energy sources.

According to IEA data, 90% of the LAC energy demand in 2020 would be covered with fossil fuels (89% in 1997). Coal would keep its 1997 share in total energy demand (6%); while oil would reduce its participation from 61% in 1997 to 53% in 2020, and gas would increase its share from 22% to 31% in that period. Nuclear and renewable sources other than hydroenergy would keep their very limited participation (1% each), and hydroenergy would account for 8% in 2020 vs. 9% in 1997 *(IEA, 2000: 402).* It is important to note that the replacement of oil by natural gas (by 8 points) shown in previous figures would partially contribute to moderate CO_2 emissions in that period.

Fossil fuel reserves are expected to decrease in several LAC countries during the next two decades *(see Annexed Tables 1-6).* According to OLADE projections, oil reserves would significantly decrease for all the sub-regions. For the Southern Cone these reserves would be exhausted in 2013.

During 2000-2020, the natural gas reserves would reduce for Central America, the Caribbean, the Andean Zone and the Southern Cone. Mexico and specially Brazil would register significant increases in this indicator. By 2020 the Andean Zone would remain as the most promising basin of natural gas in the region, with reserves for other 43 years.

Coal reserves would considerably increase in the Southern Cone, Brazil and the Andean Zone; while Mexico would register a significant reduction (more than 50%). The duration of coal reserves is expected to increase in Brazil (from 433 years in 2000 to 646 years in 2020) and the Southern Cone (from 95 years in 2000 to 180 years in 2020).

The introduction of effective programmes to promote renewable energy sources in LAC would considerably contribute to climate change mitigation and to the conservation of non-renewable energy resources, such as oil, natural gas and coal. The relative progress of LAC in terms of exploiting renewable energy sources only represented 25.4% of potential progress, according to world trends at mid 1990s *(Pichs, 1998).*

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[8] Due to lack of comparable information for LAC subregions in 1999-2015, this section is mainly based on aggregated information for LAC.

In Mexico, renewable energy was responsible for about 7% of total energy consumption in 1997. About 27% of the country's electricity generation is derived from hydroelectricity and 2% from geothermal. However, in perspective, much of the new generating capacity thought to be needed before 2006 is expected to be fuelled by natural gas rather than renewable sources *(see EIA, 2000: 97-98).*

In Central and South America[9] hydropower provides about 60% of electricity: 87% in Brazil[10], 43% in Argentina, 59% in Venezuela, and 53% in Chile. However, this situation is expected to change, with several countries orienting most of new investment in electric capacity to thermal energy[11], as part of the regional tendency to diversify electricity sources. For Central and South America, hydroelectricity and other renewable energy use is projected to increase by only 1.4% per year (0.4% a year in Brazil) during 1997-2020 *(see EIA, 2000: 98).* This trend of growing use of thermal energy for electricity generation in LAC would have adverse effects in terms of climate change mitigation.

Recent Brazilian experience provides an example of massive promotion of renewable energy sources in rural areas. In an effort to provide electricity to people who are not connected to the national power grid, the Brazilian government has committed to invest 25 billion dollars to increase the number of renewable energy installations in the country. *Programa de Desenvolvimento Energetico de Estados e Municipios (Prodeem)* plans to develop 20,000 MW of renewable energy capacity for the 20 million rural inhabitants without access to electricity in Brazil, in the next two decades *(EIA, 2000: 98).* This project links the sustainable development goals of benefited sectors of rural population in Brazil with national efforts to mitigate climate change.

In the transportation sector, the Brazilian government has been encouraging the automotive industry to increase the production of ethanol-fuel cars. The production of ethanol-fuelled cars achieved 96% market share in 1985 but declined to 3.1% in 1995 and 0.1% in 1998 *(IPCC, 2001a: WGIII, Chapter 3).*

Regarding the impressive potential of renewable energy sources in LAC, it is worth recalling that:

- *LAC accounts for around 25% of the economic potential for hydropower in the world (see Annexed Table No. 7).*

- *LAC also has a significant potential of solar energy. The annual solar energy potential ranges from a minimum level of 112.6 Exajoules (EJ) to a maximum of 3,385 EJ.*

[9] Includes the Andean Zone, Brazil and the Southern Cone.
[10] Itaipú, on the border of Brazil and Paraguay, is the most powerful hydropower dam built to date, with a capacity of 12,600 megawatts of electricity, and a total cost of 20 billion dollars *(UNDP-DESA-WEC, 2000: 77).*
[11] Central and South America would rely increasingly on natural gas as a fuel for new electricity generation. The share of electricity market supplied by generation from gas-fired power plants is expected to grow from 11% in 1997 to 34% in 2020, according to EIA (2000: 122).

Table 2.7
Annual solar energy potential (Exajoules)

	Minimum	Maximum
LAC	112.6	3,385
World	1,575	49,837

Source: UNDP-DESA-WEC, 2000: 163.

- *Concerning the potential for bioenergy, Latin America is currently using only 15% of its potential cropland (23% in 2025). The remaining cropland could be used for biomass production (see Annexed Table 8)*

- *In 1997 total production of geothermal electricity in LAC amounted to 6.9 Twh_e; around 16% of world total. Annual geothermal potential for LAC is 26,000,000 Exajoules (18.6% of the world total) (UNDP-DESA-WEC, 2000: 165 y 255).*

- *Regarding* wind energy*, the theoretical wind potential for LAC is 53,000 Twh, according to estimates of WEC. WEC also suggests a more conservative figure of 2,100 Twh, assuming for practical reasons that just 4% of the area expose to this wind can be used for wind farms.*

Table 2.8
Estimated annual wind energy resources

	Wind energy resources Without land restriction		Wind energy resources if less than 4% of land is used	
	Thousands of Terawatts-hours	Exajoules	Thousands of Terawatts-hours	Exajoules
LAC	53	636	2.1	25
Total	483	5,800	18.7	231

Source: UNDP-DESA-WEC, 2000: 164

In general terms, renewable energy sources have an important role to play in climate change mitigation strategies in LAC. Even considering that this potential is not equally distributed among LAC countries, potential for small-scale projects for harnessing renewable energy sources can be identified in most of the region. With regard to current climate change negotiations, CDM executive board shall develop and recommend to the COP, at its eighth session, simplified modalities and procedures to three categories of small scale CDM projects, including renewable energy project activities with a maximum output capacity equivalent of up to 15 megawatts.

In general, it has been recognised that reducing energy-related CO_2 through increasing energy efficiency and promoting the use of renewable energy sources has considerable potential, but realising this potential will require removing obstacles to wider diffusion of sustainable energy technologies; developing market signals that reflect environmental costs of the various energy carriers, and encouraging technological innovation.

In this sense, the liberalisation and privatisation process, carried out in LAC during the last two decades, has had contradictory effects, leading in many cases to a reversion of previous progress in the use of renewable energy sources with negative effects for climate change mitigation *(see Pichs, Swart, Leary and Ormond, eds., 2000: 3-4).* In Argentina and Brazil, for instance, market reforms are expected to encourage natural gas at the expense of electricity generated by large hydropower schemes, raising GHG emissions. Under these conditions, the current process of energy market restructuring is far from contributing to the long-term vision compatible with sustainable energy policies and their successful application.

2.3. Two Alternative Scenarios to the OLADE Projections for Energy-Related CO_2 Emissions

With the intention of providing a general idea of the potential reduction in energy-related CO_2 emissions that could be achieved in LAC, this paper offers two simple alternative trends, only for reference purposes:

*Reference Scenario***:** Total energy-related CO_2 emissions for LAC in 1999-2015, according to OLADE database, in Gg *(OLADE, 2001).*

Alternative 1: Projection of total energy-related CO_2 emissions for LAC in 1999-2015, assuming:

- the same average growth rate per year that in the previous 15 years (1984-99);
- this alternative scenario would consider not to affect the achievement of socio-economic priorities implicit in the OLADE trends, but to achieve those goals with greater efficiency, and increased use of renewable energy sources.

Alternative 2: Projection of total energy-related CO_2 emissions in 1999-2015, assuming:

- an increase of GDP of 6% a year in 1999-2015, as proposed by ECLAC as the required rate to overcome the technological and social backwardness in LAC;
- the same coefficient of CO_2 emissions / GDP than in the 1990s.

2.3.1. Alternative 1

This simple alternative projection was calculated for LAC, and for each of the subregions considered in this paper: Andean Zone, the Caribbean, Central America, the Southern Cone, Mexico and Brazil *(see Annexed Charts 1-6).*

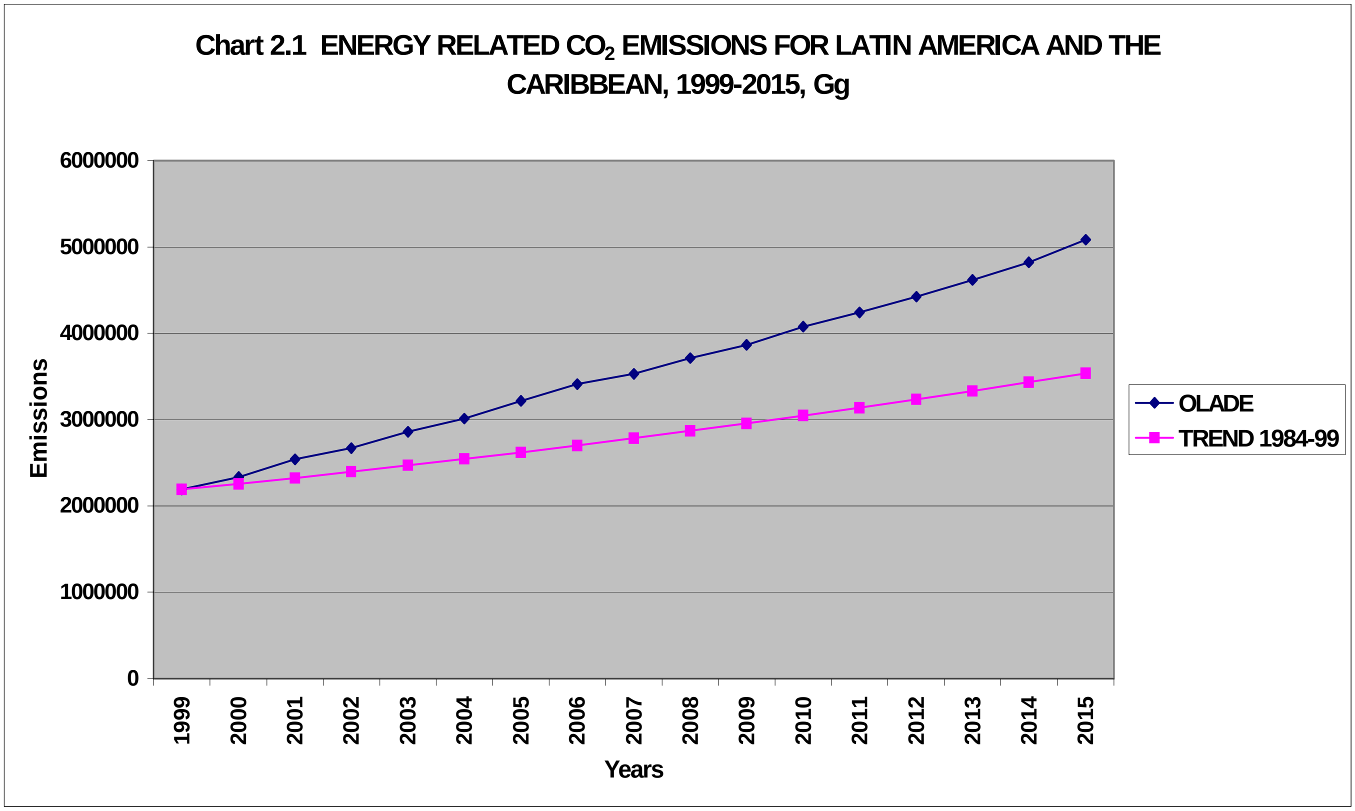

Chart data:

Years	(A) OLADE	(B)T/1984-99	(C)=(A)-(B)
1999	2189433.6	2189433.6	0.0
2000	2334894.4	2255992.4	78901.9
2001	2538693.2	2324574.6	214118.6
2002	2671262.0	2395241.6	276020.3
2003	2857776.8	2468057.0	389719.8
2004	3009414.7	2543085.9	466328.8
2005	3214615.5	2620395.7	594219.7
2006	3412667.0	2700055.8	712611.2
2007	3527896.2	2782137.5	745758.7
2008	3712762.3	2866714.4	846047.9
2009	3862615.2	2953862.6	908752.6
2010	4078003.1	3043660.0	1034343.1
2011	4239350.9	3136187.2	1103163.6
2012	4422735.1	3231527.3	1191207.8
2013	4614693.9	3329765.8	1284928.1
2014	4821689.8	3430990.6	1390699.2
2015	5085173.5	3535292.8	1549880.7

Sources: Based on *OLADE (2001)*

Table 2.9
Results of the projection under Alternative 1

A: General results

Indicators	***Reference Scenario***	***Alternative 1***
• Implicit growth rate of CO_2 emissions per year (%)	5.41	3.04
• CO_2 emissions reduction	---	13 Gigatons of CO_2. Estimated cost of mitigation: 390 billion US$ ⇔ 24 billion US$ per year[12]

B: Summary of the subregional contribution to total saving (CO_2 emission reduction)

Subregions	**% of total saving**
Andean Zone	39.3
Southern Cone	20.5
Brazil	17.1
México	14.6
Caribbean	7.9
Central America	0.6

Note: For the subregional results, see *Annexed Charts 1 to 6.*

2.3.2. Alternative 2

This alternative projection was only calculated for LAC, because no ECLAC target for the subregions is available.

[12] Assuming an estimated mitigation cost for LAC (as a conservative figure) = 30 US$/tn CO_2 (see Suárez, 2000).

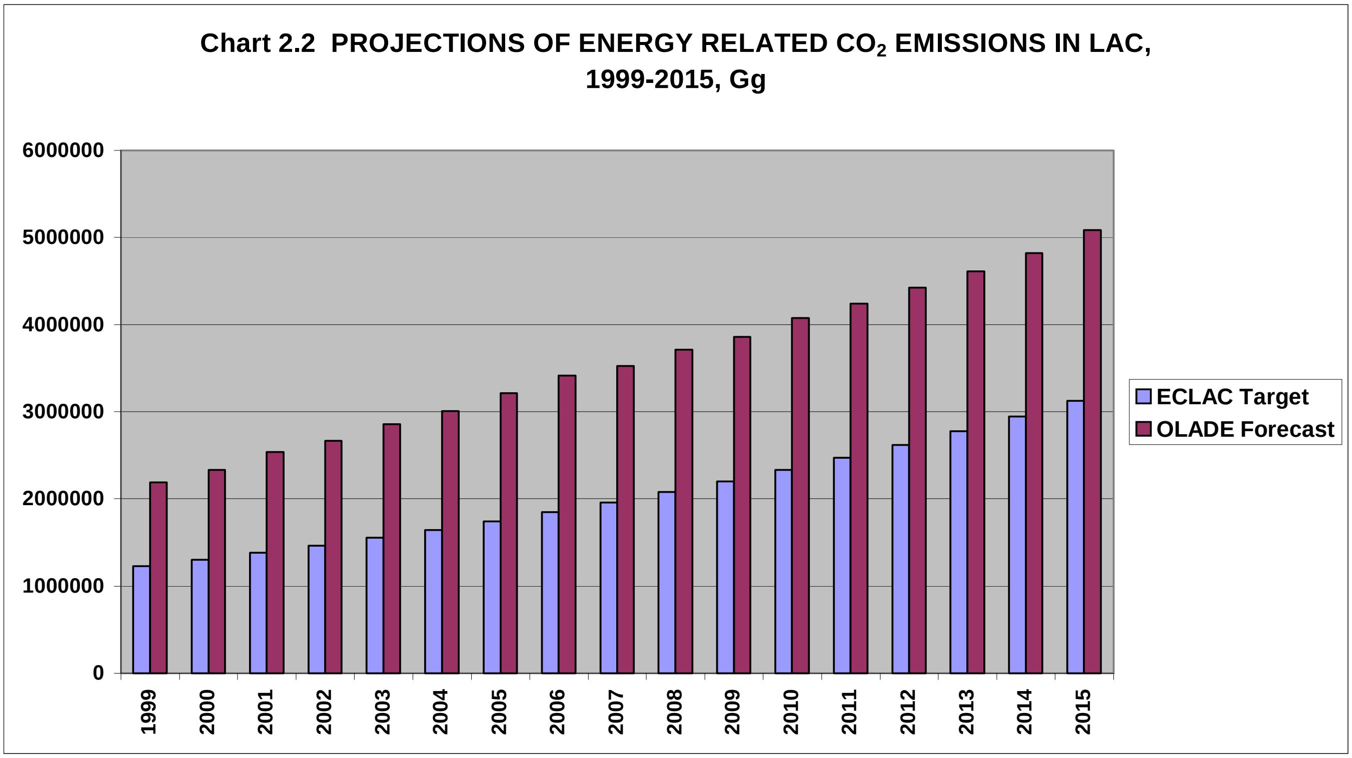

Chart data

Years	A GDP LAC million U$D[13]	B EMISSIONS (1) Gg	C EMISSIONS (2) Gg	D (2)-(1) Gg
	ECLAC Target (6%)			
1999	1382038.7	1230014	2189434	959419
2000	1464961.0	1303815	2334894	1031079
2001	1552858.6	1382044	2538693	1156649
2002	1646030.2	1464967	2671262	1206295
2003	1744792.0	1552865	2857777	1304912
2004	1849479.5	1646037	3009415	1363378
2005	1960448.3	1744799	3214615	1469817
2006	2078075.2	1849487	3412667	1563180
2007	2202759.7	1960456	3527896	1567440
2008	2334925.3	2078083	3712762	1634679
2009	2475020.8	2202768	3862615	1659847
2010	2623522.0	2334935	4078003	1743069
2011	2780933.3	2475031	4239351	1764320
2012	2947789.3	2623533	4422735	1799203
2013	3124656.7	2780944	4614694	1833749
2014	3312136.1	2947801	4821690	1873889
2015	3510864.3	3124669	5085173	1960504

[13] At 1980 prices.

(1) Column A x 0.89 kg/U$D (Level of Emissions/GDP in the 1990s)
(2) OLADE Projection
Sources: Based on OLADE (2001) and CEPAL (2000b)

CO_2 emission reduction (saving): *26 Gigatons of CO_2.*
Estimated cost: 780 billion US$ ⇔ 46 billion US$ per year[14]

This exercise, based in simple projections, confirms the significant potential existing in LAC for combining CC mitigation in the energy sector and proper consideration of sustainable development priorities of the region. Under *Alternative 1 projection*, the saving of CO_2 compared to OLADE projections would amount to 13 Gigatons of CO_2, with the Andean Zone accounting for 39% of this saving. The estimated mitigation cost for *Alternative 1 projection* is 24 billion US$ per year.

Under *Alternative 2 projection*, the saving of CO_2 compared to OLADE projections would amount to 26 Gigatons of CO_2, with an estimated mitigation cost of 46 billion US$ per year.

In both projections the CO_2 saving are indicative data, only for reference purposes. Realising this potential would have considerable implications in terms of investments and technological transformations.

2.4. Illustrative Exercise Regarding LAC Potential for Reducing Energy-Related CO_2 Emissions and Human Development

Previous sections have referred to the LAC potential to reduce energy-related CO_2 emissions by increasing energy efficiency and encouraging the replacement of fossil fuels by renewable energy sources, with references to expected trends in key socio-economic sectors as industry, residential sector and transportation.

This section introduces and exercise that confirms the potential for LAC to progress in its adjustment to the patterns of a new energy paradigm based in energy efficiency and greater use of renewable energy sources. This exercise considers a sample of 13 LAC countries that accounted for 92% of LAC energy-related CO_2 emissions in 1999.

This integrative exercise links two basic indexes presented in Chapter I:

- *Index I (IANPE):* Index of Adjustment to the New Energy Paradigm[15], indicating the relative position of LAC countries in terms of energy efficiency and use of less CO_2 intensive fuels.
  Possible values: 0-1; where "0" indicates no adjustment to the patterns of the new energy paradigm and "1" indicates maximum adjustment

[14] Assuming an estimated mitigation cost for LAC (as a conservative figure) = 30 US$/tn CO_2 (see Suárez, 2000).
[15] This Index was calculated for 65 countries in *Pichs (1998), and was called (in Spanish) Indice de Ajuste al Nuevo Paradigma Energético (IANPE).*

- *Index II (HDI):* Human Development Index[16].

Possible values: 0-1

As can be observed in Chart 2.3, the average value of IANPE for LAC was only 0.5152. In other words, the relative adjustment of LAC to the patterns of the new energy paradigm by mid 1990s was only 51.5%, in relative terms. The average adjustment for developed countries was 66.3%, and the corresponding average value for the developing countries was 44.3%.

Four of the analysed LAC countries registered a level of IANPE below the average value of all developing countries: Bolivia (38%), Guatemala (41%), Ecuador (41.7%) and Trinidad-Tobago (43.1%).

The average HDI for LAC was 75.4% in 2000, and the corresponding figures for the OECD and developing countries were 89.3% and 64.2%, respectively.

According to Chart 2.3, most the LAC countries included in this exercise registered a medium level of IANPE and HDI (values between 0.500 and 0.799): Mexico, Venezuela, Colombia, Brazil, Jamaica and Paraguay. Four countries showed a medium level of HDI with low level of IANPE (values between 0 and 0.499): Trinidad-Tobago, Ecuador, Bolivia y Guatemala. The remaining three countries registered high levels of HDI (values from 0,8 to 1) with medium levels of IANPE: Argentina, Chile and Uruguay.

This illustrative exercise also confirms the exiting potential in LAC in terms of adjustment to the patterns of the new energy paradigm in terms of energy efficiency and promotion of renewable energy sources. The exercise also reveals the necessity to improve the HDI by introducing indicators concerning the environmental dimension of sustainable development.

[16] Calculated by *UNDP (2000)* for 174 countries.

Chart 2.3 HDI-IANPE in LAC

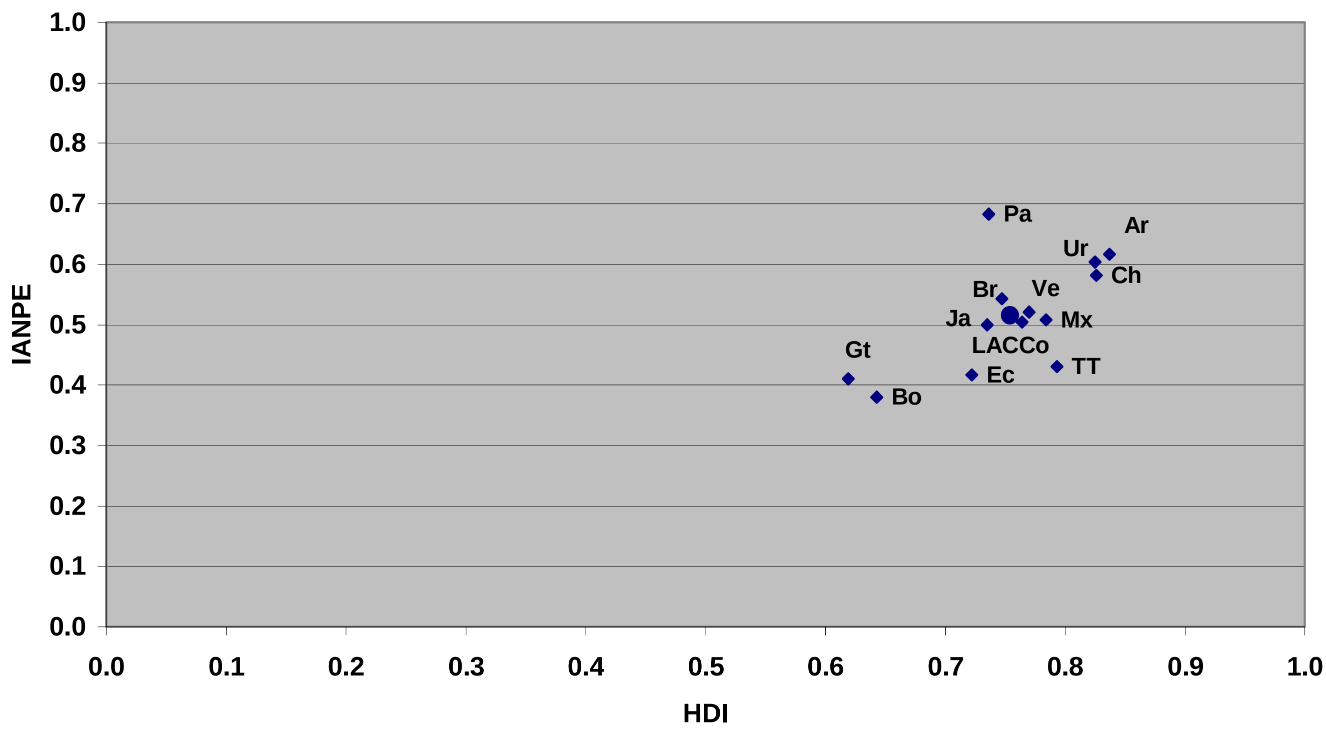

Chart data:

COUNTRIES		IANPE	HDI
PARAGUAY	Pa	0.683	0.736
ARGENTINA	Ar	0.616	0.837
URUGUAY	Ur	0.603	0.825
CHILE	Ch	0.582	0.826
BRAZIL	Br	0.543	0.747
VENEZUELA	Ve	0.520	0.770
MEXICO	Mx	0.508	0.784
COLOMIA	Co	0.505	0.764
JAMAICA	Ja	0.500	0.735
T-TOBAGO	TT	0.431	0.793
ECUADOR	Ec	0.417	0.722
GUATEMALA	Gt	0.410	0.619
BOLIVIA	Bo	0.380	0.643
LAC	**LAC**	**0.515**	**0.754**[17]

Sources: UNDP (2000) and Pichs (1998)

[17] This refers to the 13 countries of the sample. The average for all LAC countries was 0.758 *(see UNDP, 2000).*

2.5. Synthesis Concerning LAC Potential for Reducing Energy-Related CO_2 Emissions.

By using regional data for commercial energy use per capita (1997) and total energy intensity (1997-98), this paper proposes a statistical exercise to provide some reference points in assessing the potential for reducing energy-related CO_2 emissions in LAC countries.

As part of this exercise, two simple indexes were elaborated:

- *Index A: Commercial Energy coverage per capita*. This index is based on data for commercial energy use per capita (1997), according to UNDP (2000) data. This index is a gross indicator of commercial energy coverage, and energy requirements for LAC countries. The main assumption of this index is that countries with low levels of commercial energy use per capita show low levels of energy coverage (low electricity coverage and restricted use of commercial fuels in the residential sector, for instance). Therefore, they require greater investments to increase sustainable energy coverage.

  The range of possible values for this index are: 0-1; where "0" indicates minimum commercial energy coverage in the region and "1" maximum commercial energy coverage, in relative terms, within the LAC context.

  Formulation: *Ii = (Xi-Xmin)/(Xmax-Xmin)*[18]*;* where;
  - **Ii** is the value of the index for the country "i";
  - **X:** Commercial energy use per capita (1997), UNDP figures.
  - **Xi:** value of X in the country "i";
  - **Xmax:** maximum value of X in the sample; in this case = 2526 Kg oil equivalent per capita, corresponding to Venezuela[19].
  - **Xmin:** minimum value of X in the sample; in this case = 237 Kg oil equivalent per capita, corresponding to Haiti.

- *Index B: Total energy intensity*. This index is based on data for total energy (traditional + commercial) intensity in 1997-98, according to UNDP and OLADE data. This index is a gross indicator of the relative attractiveness of LAC countries for investments oriented to reduce energy-related CO_2 emissions. The main assumption behind this index is that countries with higher total energy intensity are relatively more attractive than countries with lower records in this indicator. This assumption is based on the consideration that the higher the total energy intensity in a country, the lower marginal costs of abatement for reducing energy-related CO_2 emissions tend to be[20].

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[18] Following the procedure for calculating the Human Development Index (see UNDP, 2000).
[19] The figure for *Trinidad and Tobago = 6414 Kg oil equivalent per capita* is an extreme value in the LAC context. For this reason this figure was not selected as the maximum value in this exercise.
[20] It is worth noting that this exercise does not analyse other factors affecting the attractiveness for reducing energy-related CO_2 emissions, such as institutional, market and information limitations/barriers, political risks and other investment risks.

The range of possible values for this index are: 0-1, where "0" indicates minimum attractiveness, and "1" indicates maximum attractiveness, in relative terms, within the LAC context.

Formulation*: Ii = (Xi-Xmin)/(Xmax-Xmin)*[21]*;* where:

- **Ii** is the value of the index for the country "i";
- **X:** Total energy intensity in 1997-98, according to calculations based on UNDP (2000) and OLADE (2001) figures.
- **Xi:** value of X in the country "i";
- **Xmax:** maximum value of X in the sample; in this case = 1.6 Kg oil equivalent per US$ of GDP corresponding to Nicaragua[22].
- **Xmin:** minimum value of X in the sample; in this case = 0.3 Kg oil equivalent corresponding to Argentina.

As can be observed in Chart 2.4, most of the LAC countries (14 out of 22[23] countries considered in this exercise) show levels of commercial energy use per capita below the regional average: Haiti, Nicaragua, Honduras, Guatemala, Paraguay, El Salvador, Bolivia, Peru, Dominican Republic, Ecuador, Colombia, Costa Rica, Panama y Uruguay. However only the first six countries of that list have higher attractiveness for reducing energy-related CO_2 emissions than the regional average.

The remaining eight countries show relatively high levels of commercial energy use per capita with regard to the regional average: Venezuela, Trinidad-Tobago, Jamaica, Cuba, Argentina, Chile, Mexico and Brazil; with the first four countries of that list registering higher attractiveness for reducing energy-related CO_2 emissions than the regional average.

According to the subregional analysis, the Southern Cone, the Andean Zone and the Caribbean register levels of commercial energy use per capita relatively higher than the regional average, but below 0.5 in a scale of "0 to 1"; while Central America shows a lower record than the regional average in this indicator. The most attractive subregions for investments in sustainable energy are the Caribbean and Central America.

[21] Following the procedure for calculating the Human Development Index (see UNDP, 2000).
[22] The figure for *Haiti = 6.08 Kg oil equivalent per US$ of GDP* is an extreme value in the LAC context. For this reason this figure was not selected as the maximum value in this exercise.
[23] Suriname, Guyana, Grenada and Barbados were not included in this exercise due to lack of comparable data for these countries.

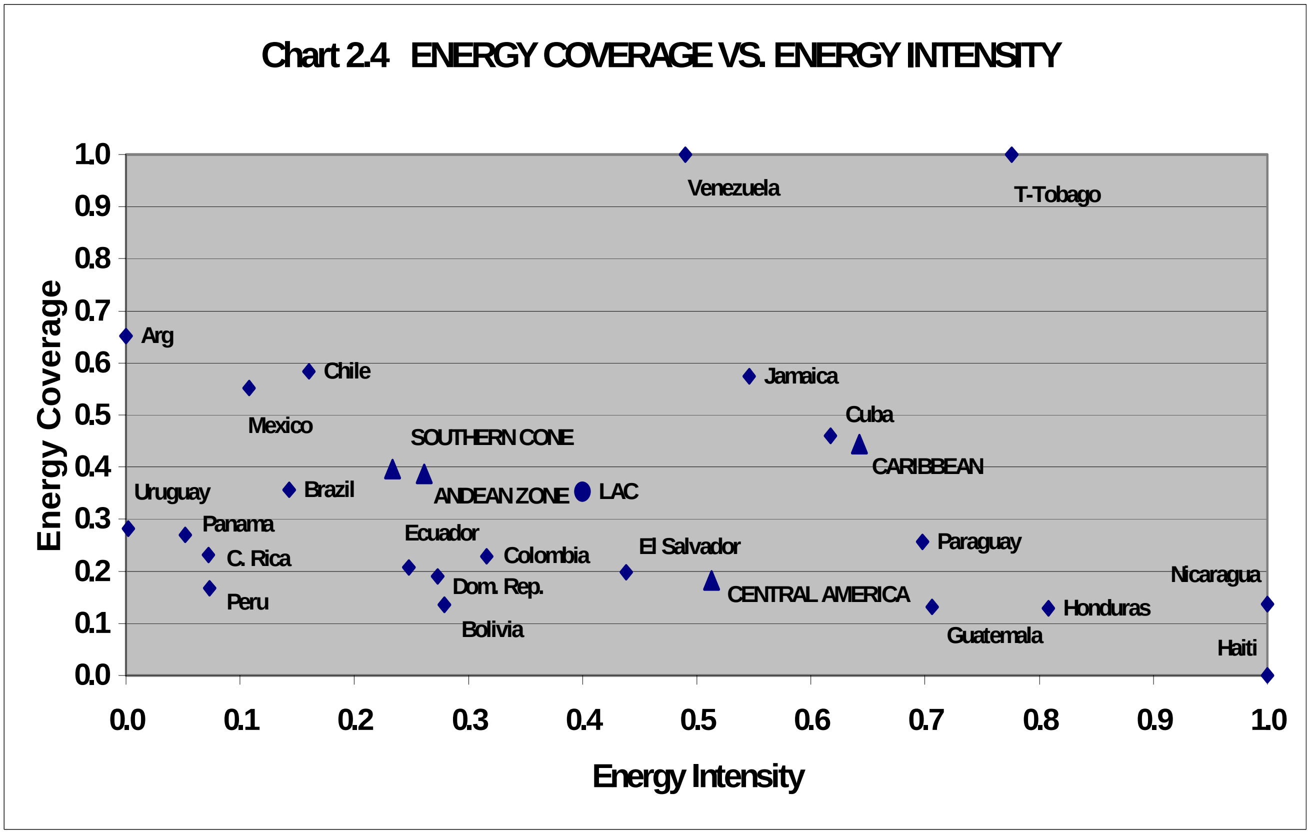

Chart Data[24]:

Countries	Index A	Index B
Argentina	0.652	0.000
Bolivia	0.136	0.279
Brazil	0.356	0.143
Chile	0.584	0.160
Colombia	0.229	0.316
Costa Rica	0.232	0.072
Cuba	0.460	0.617
Dominican Republic	0.190	0.273
Ecuador	0.208	0.248
El Salvador	0.198	0.438
Guatemala	0.131	0.706
Haiti	0.000	1.000
Honduras	0.129	0.808
Jamaica	0.574	0.546
Mexico	0.552	0.108
Nicaragua	0.137	1.000
Panama	0.270	0.052
Paraguay	0.256	0.698
Peru	0.168	0.073
T. Tobago	1.000	0.776
Uruguay	0.282	0.002
Venezuela	1.000	0.490
LAC	**0.352**	**0.400**
CARIBBEAN	**0.445**	**0.642**
CENTRAL A.	**0.183**	**0.513**
SOUTHERN C.	**0.397**	**0.233**
ANDEAN ZONE	**0.388**	**0.261**

Sources: Own calculations based on UNDP (2000) and OLADE (2001). See Annexed Table 12.

[24] Regional and subregional results were calculated as simple averages of the corresponding national indexes.

2.6. Lessons for CDM implementation

In summary, *some general lessons can be drawn for CDM implementation* from the previous analysis of CC mitigation in the energy sector:

- The potential for CC mitigation in the energy sector is different from the CDM potential, due to several provisions in CDM design, such as additionality issues, eligibility provisions, the costs associated to CDM project cycle (monitoring costs, for instance) and others.
- The investment requirements for the energy sector in LAC in the next two decades considerably exceed the potential flows of financial resources that could be provided by CDM[25].
- In this context of competition for very limited resources, special priority should be given to those projects that combine CC mitigation with sustainable development priorities, in terms of development, equity and sustainability. Some examples include increasing rural electrification with renewable energy sources; providing more energy efficient technologies for using traditional fuels; promoting the transition from inefficiently-used traditional fuels to less pollutant fuels in the residential sector, among others.
- The least developed subregions (Central America, the Caribbean and the Andean Zone in the LAC context) would be particularly interested in CDM projects in the energy sector due to their deficits of sustainable energy coverage and their growing financial and technological constraints.
- The least developed subregions (Central America, the Caribbean and the Andean Zone in the LAC context) would be the more attractive for CDM projects due to the lower marginal abatement costs associated to their relatively lower level of economic development and their greater potential for reducing energy intensity. However, investment risks and other potential costs derived from CDM project cycle (monitoring, for instance) can change initial considerations regarding relative attractiveness for CDM project activities.
- Even considering that the potential for renewable energy sources is not equally distributed among LAC countries, potential small scale projects for harnessing this kind of energy can be identified in most of the region.

[25] For instance, investment requirements for new power capacity in LAC amount to 16 billion dollars per year in 1997-2020 (IEA, 2000); however the expected economic market for CDM could be between 5 and 10 billion dollars per year for all the developing countries *(see National Strategy Studies, Ministerio del Medio Ambiente, The World Bank, 2000).*