

**ENERGY SUSTAINABILITY IN LATIN AMERICA :
carbon dioxide emissions from the energy system in the nineties
by Emilio Lebre La Rovere and Luiz Pinguelli Rosa**

1. **Table 1 : Population and GDP (gross domestic production in billion 1990 dollars at market exchange rates) in Latin America and Four Selected Countries, 1990-1993**
 2. **Table 2 : Population and GDP in the World and Selected Regions, 1990-1993**
 3. **Table 3 : Energy Intensity, Supply/Demand Ratio, Carbon Intensity and CO2 emissions/capita in Latin America and Four Selected Countries, 1990-1993**
 4. **Table 4 :Indices in the World and Selected Regions, 1990-1993**
 5. **Table 5 : CO2 Emissions from Combustion of Coal, Oil & Natural Gas, 1990-1996**
 6. **References**
-

There are several ways of defining the Latin American region. Throughout this paper we will consider Latin America as including twenty six countries from the various regions of the american continent as follows :

- 1 North American country : Mexico
- 6 countries in Central America : Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua and Panama
- 7 countries in the Caribbean : Barbados, Cuba, Grenada, Haiti, Jamaica, Dominican Republic and Trinidad and Tobago
- 12 South American countries : Argentina, Bolivia, Brazil, Colombia, Chile, Ecuador, Guyana, Paraguay, Peru, Surinam, Uruguay and Venezuela.

All of these countries have ratified the FCCC and are listed as non-Annex I Parties, with the sole exception of Surinam. So far, only Argentina has delivered its first national communication to the Convention. Venezuela and Mexico have their reports ready and are expected to deliver them soon.

Follows a brief overview of key demographic, economic and energy facts relevant to the climate change issue in Latin America. The emission data reported here will focus on carbon dioxide emissions from the combustion of fossil fuels in the energy sector, due to the large uncertainties still prevailing in the estimated figures of GHG emissions from land use change and other sources. Special attention will be given to the four largest economies in the region : Argentina, Brazil, Mexico and Venezuela.

Table 1 presents the recent evolution (1990-1993) of some key demographic and economic indicators in Latin America and its four largest countries. Table 2 provides their comparison to Africa, Asia, OECD and the world averages.

Generally speaking, income per capita levels in Latin America are located in an intermediate position between OECD (8 times higher in 1990) and the developing countries in Africa and Asia, but still 40 % below the world average. However, it should be warned that these figures

are only indicative as GDP levels at market exchange rates are not accurate for international comparisons.

A key distinctive feature of Latin America is its advanced stage in the demographic transition compared with other developing countries, with medium population growth (1.6 % per year) and high urbanization rates (roughly 75 % of total population live in cities).

Table 1 : Population and GDP (gross domestic production in billion 1990 dollars at exchange rates) in Latin America and Four Selected Countries, 1990-1993

Selected Indicators	Argentina	Brazil	Mexico	Venezuela	Latin America
Popul. 1990 (million)	32.3	144.1	86.0	19.4	438
% Lat Am. Pop. 1990	7.4	32.9	19.6	4.4	100
Popul. 1993 (million)	33.4	152.7	91.0	20.8	459
Pop. Gr. %/y 1990-93	1.2	1.9	1.9	2.2	1.6
GDP 1990 (bill. US\$)	140.4	347.4	244.5	48.6	1,056
% Lat Am. GDP 1990	13.3	32.9	23.2	4.6	100
GDP 1993 (bill. US\$)	176.2	363.0	262.3	56.6	1,166
GDP Gr. %/y 1990-93	8.0	1.5	2.3	5.2	3.3
GDP/cap 90 (US\$/y)	4,347	2,411	2,843	2,505	2,411
% L.A. GDP/cap 90	180	100	118	104	100
GDP/cap 93 (US\$/y)	5,275	2,377	2,882	2,721	2,735
GDP/c Gr. %/y 90/93	6.8	-0.4	0.4	3.0	1.7

Sources : OECD/IEA, 1996; MME, 1996 in Rosa and La Rovere, 1997

Table 2 : Population and GDP in the World and Selected Regions, 1990-1993

Selected Indicators	Africa	Asia	OECD	World	Latin Amer
Popul. 1990 (million)	625	2,812	854	5,257	438
% World Pop. 1990	11.9	53.5	16.2	100	8.3
Popul. 1993 (million)	675	2,890	872	5,517	459
Pop. Gr. %/y 1990-93	2.6	0.9	0.7	1.6	1.6
GDP 1990 (bill. US\$)	389	1,662	16,471	21,425	1,056
% World GDP 1990	1.8	7.8	76.9	100	4.9
GDP 1993 (bill. US\$)	398	2,025	17,087	21,862	1,166
GDP Gr %/y 1990-93	0.7	6.8	1.2	0.7	3.3
GDP/cap 90 (US\$/y)	622	591	19,282	4,076	2,411
% World GDP/cap 90	15.3	14.5	473	100	59.2
GDP/cap 93 (US\$/y)	590	701	19,593	3,963	2,735
GDP/c Gr. %/y 90/93	-1.9	5.9	0.5	-0.9	1.7

Note : Asia excludes FSU; OECD excludes Mexico, Hungary and the Czech republic
Source : OECD/IEA, 1996 in Rosa and La Rovere, 1997

It is also interesting to note the important weight of the four largest economies within Latin America, adding up to 60 % of population and 74 % of GDP in the region, as of 1990. In the early nineties, latin american economies were growing at reasonable rates, faster than world average and population growth rates, with the important exception of Brazil. Economic growth in the region was further accelerated since 1993, now including the Brazilian economy which also started to grow again over 4 % per year after 1993. This performance lies between the extremes of the past two decades : the rapid growth during the seventies (when the regional economy increased by 37 %) and the recession in the eighties (8 % overall decrease).

Economic activity is known to be one of the major drivers of CO2 emissions from the energy sector, the main source of GHG emissions in the region, with the important exception of Brazil, where CO2 emissions from deforestation in the Amazon are 2 to 3 times higher than current levels from the combustion of fossil fuels. Accordingly, the moderate rates of economic growth in the nineties are associated to an average increase of 2.1 % per year of the latinamerican CO2 emissions from the combustion of fossil fuels in the period 1990/96 (see Jefferson, 1997a). This pace of growth corresponds to exactly the same average historical rate of increase in these CO2 emissions from 1970 (664 million tons) to 1990 (1 billion tons), a balanced result of two very different decades in Latin America (see OLADE, 1996).

However, other important drivers of energy-related CO2 emissions have also to be considered. A closer look to them is provided by the well known Kaya identity already used in previous works (Kaya, 1989; Rosa and Tolmasquim, 1993) :

$$\text{CO2 emissions/capita} = \text{GDP/capita} \times \text{TFEC/GDP} \times \text{TPES/TFEC} \times \text{CO2 /TPES},$$

where

TFEC = total final energy consumption (million toe-tons of oil equivalent)

TFEC/GDP = energy intensity of the economy (million toe / billion US\$)

TPES = total consumption of primary energy sources (million toe)

TPES/TFEC = energy supply to demand ratio, or the inverse of energy sector efficiency

CO2 /TPES = carbon intensity of the energy supply-primary fuels mix (tons CO2 /toe).

Table 3 presents the recent evolution (1990-1993) of the above identity elements and the total CO2 emissions in Latin America and its four largest countries. Table 4 provides their comparison to Africa, Asia, OECD and the world averages.

Again, CO2 emissions per capita levels in Latin America are located at an intermediate position between OECD (5.5 times higher in 1990) and the developing countries in Africa and Asia, but still 47 % below the world average. Latinamerican energy supply/demand ratio and the carbon intensity are not far from OECD levels.

However the energy intensity of its economy is 60 % higher than in the OECD. The main driving factor of the different levels of CO2 emissions per capita remains the gap in the income per capita.

Table 3 : Energy Intensity, Supply/Demand Ratio, Carbon Intensity and CO₂ emissions/capita Latin America and Four Selected Countries, 1990-1993

Selected Indicators	Argentina	Brazil	Mexico	Venezuela	Latin America
GDP/cap 90 (th.US\$)	4.35	2.41	2.84	2.51	2.41
TFEC/GDP 1990	0.20	0.49	0.39	0.56	0.28
TPES/TFEC 1990	1.47	1.11	1.34	1.51	1.31
CO ₂ /TPES 1990	2.38	1.31	2.42	2.44	2.41
tons CO ₂ /capita 90	3.07	1.71	3.58	5.20	2.15
Total mill. tCO ₂ 90	99.2	246.0	308.2	100.6	945.0
GDP/cap 93 (th.US\$)	5.28	2.38	2.89	2.72	2.74
TFEC/GDP 1993	0.20	0.50	0.39	0.58	0.29
TPES/TFEC 1993	1.35	1.10	1.33	1.44	1.27
CO ₂ /TPES 1993	2.38	1.35	2.40	2.36	2.38
tons CO ₂ /capita 93	3.38	1.77	3.55	5.35	2.37
Total mill. tCO ₂ 93	113.1	271.0	323.4	111.2	1,012.5

Note : emissions from coal, gas and oil only; for Brazil, 1 MWh hydro = 0.29 toe

Source : Rosa and La Rovere, 1997

Table 4 : Indices in the World and Selected Regions, 1990-1993

Selected Indicators	Africa	Asia	OECD	World	Latin Amer
GDP/cap 90 (th.US\$)	0.62	0.59	19.28	4.08	2.41
TFEC/GDP 1990	0.32	0.54	0.18	0.26	0.28
TPES/TFEC 1990	1.66	1.36	1.39	1.42	1.31
CO ₂ /TPES 1990	3.10	3.30	2.48	2.70	2.41
tons CO ₂ /capita 90	1.02	1.43	11.86	4.07	2.15
Total mill. tCO₂ 90	638.9	4,003.8	10,126	21,428.8	945.0
GDP/cap 93 (th.US\$)	0.59	0.70	19.59	3.96	2.74
TFEC/GDP 1993	0.32	0.51	0.18	0.26	0.29
TPES/TFEC 1993	1.67	1.38	1.41	1.44	1.27
CO ₂ /TPES 1993	3.08	3.27	2.42	2.66	2.38
tons CO ₂ /capita 93	0.98	1.60	11.80	3.90	2.37
Total mill. tCO₂ 93	662.8	4,623.2	10,293	21,480.3	1,012.5

Source : OECD/IEA, 1996

Within Latin America, the four largest economies are responsible for 80 % of the CO₂ emissions in the region. The case of Brazil is worth mentioning as an example of extremely high efficiency of the energy sector and its very low carbon intensity, compared with OECD levels. This is due to the essential role of renewables in the Brazilian energy balance, accounting for more than half of the total primary energy consumption : 92 % of electricity comes from hydropower, ethanol and bagasse from sugar cane contribute 10 % to primary energy supply and charcoal from afforestation schemes feed a non negligible proportion of Brazilian pig iron and steel industry. However, current trends of the Brazilian energy picture point to a decrease in the share of renewables in the fuel mix due the deregulation of energy sector. The consequences are: the lack of an energy policy to support the alcohol programme, whose costs are higher than those of gasoline; the privatization of the power sector moves it from hydroelectricity to thermopower (Rosa and Ribeiro, 1992; Rosa and Tolmasquim, 1993); finally privatization of steel industry is followed by a move from charcoal towards coke, respectively (La Rovere, 1996).

In most of the other latinamerican countries, as well as in various parts of the world, the penetration of natural gas in the fossil fuel mix during the nineties is leading to a slow

decrease in the carbon intensity of the energy supply, as shown in Table 5 by the most recent data available covering the period from 1990 to 1996.

According to the IEA's World Energy Outlook, significant growth of energy-related CO₂ emissions is expected in Latin America between 1990 and 2010 : from 63 to 80%, under the two cases of the outlook, compared to the 52 % increase recorded in the 1970-1990 period. As global energy-related CO₂ emissions are projected to grow by 17 to 30 % during the same period, the latinamerican share in this world total would increase from 5 % in 1996 to 6 % in 2010. Still, the increase in latinamerican energy-related CO₂ emissions until 2010 foreseen by the IEA is much more modest than in Africa (84 to 92 % growth) and in Asia, where they are expected to more than double, while the current trend of slow growth in the OECD region is projected to continue until well into the next century (IEA, 1996).

Table 5 : CO₂ Emissions from Combustion of Coal, Oil & Natural Gas, 1990-1996

Selected Indicators	Africa	As./Pac	OECD	World	Latin Amei
Total 1990 (mill. tons)	671.0	5,606.3	11,128	22,436.3	1,052.3
Coal 1990 (mill. tons)	300.7	3,311.0	3,732.7	8,745.0	95.3
Coal 1990 (%)	44.8	59.1	33.5	39.0	9.1
Oil 1990 (mill. tons)	293.3	1,987.3	5,423.0	9,654.3	770.0
Oil 1990 (%)	43.7	35.4	48.7	43.0	73.2
Nat.Gas 90 (mill.tons)	77.0	308.0	1,972.7	4,037.0	187.0
Nat. Gas 1990 (%)	11.5	5.5	17.7	18.0	17.8
Total 1993 (mill. tons)	693.0	6,211.3	11,565	22,432.7	1,059.7
Coal 1993 (mill. tons)	308.0	3,487.0	3,571.3	8,514.0	84.3
Coal 1993 (%)	44.4	56.1	30.9	38.0	8.0
Oil 1993 (mill. tons)	304.3	2,321.0	5,778.7	9,614.0	773.7
Oil 1993 (%)	43.9	37.4	50.0	42.9	73.0
Nat.Gas 93 (mill.tons)	80.7	403.3	2,214.7	4,304.7	201.7
Nat. Gas 1993 (%)	11.6	6.5	19.2	19.2	19.0
Total 1996 (mill. tons)	799.4	7,348.0	12,001	23,818.7	1,191.7
Coal 1996 (mill. tons)	355.7	4,121.3	3,721.7	8,968.7	91.7
Coal 1996 (%)	44.5	56.1	31.0	37.7	7.7
Oil 1996 (mill. tons)	341.0	2,728.0	5,848.3	10,204.3	854.3
Oil 1996 (%)	42.7	37.1	48.7	42.8	71.7
Nat.Gas 96 (mill.tons)	102.7	498.7	2,431.0	4,645.7	245.7
Nat. Gas 1996 (%)	12.8	6.8	20.3	19.5	20.6
90-96 Tot.change Mt	128.4	1,741.7	872.6	1,382.4	139.4
90-96 Tot.change %	19.1	31.1	7.8	6.2	13.2
90-96 Coal change	55.0	810.3	-11.0	223.7	-3.6
90-96 Coal change %	18.3	24.5	-0.3	2.6	-3.8
90-96 Oil change Mt	47.7	740.7	425.3	550.0	84.3
90-96 Oil change %	16.3	37.3	7.8	5.7	10.9
90-96 Gas change Mt	25.7	190.7	458.3	608.7	58.7
90-96 Gas change %	33.4	61.9	23.2	15.1	31.4

Asia/Pacific includes Australia, Japan and New Zeland Source : OECD/IEA, 1996b

However, the uncertainty of these projections is much larger in developing countries, due to the wide spectrum of their possible development paths, regardless of the climate change issue : even the so-called baseline scenarios cover a very large range of CO₂ emissions, according to the effect of future structural shifts during the growth process on the elements of the identity above defined (Rosa et al, 1996; Hourcade et al, 1996).

References

- Hourcade, J.C.; Richels, R.; Robinson, J. et al**; "Estimating the Cost of Mitigating Greenhouse Gases", Economic and Social Dimensions of Climate Change, IPCC Second Assessment Report, 1996, vol. 3, p.263-296.
- IEA - Instituto de Estudos Avançados**; "Projeto FLORAM - uma Plataforma", Estudos Avançados, University of Sao Paulo, vol.4, no 9, May/August 1990.
- IEA (International Energy Agency)**; "World Energy Outlook", OECD/IEA, Paris, 1996
- IPCC** ; "Climate Change 1995 - The Science of Climate Change", Working Group I Report, 1996.
- Jefferson, M.**; "Carbon Dioxide Emissions from Fossil Fuel Use : Recent Performance and Future Prospects", background paper for the Session on Differentiation versus Common Targets and Timetables, AREA Canadian National Climate Change Conference, Toronto, 24 September 1997a
- Jefferson, M.**; "Potential Climate Change : Carbon Dioxide Emissions 1990-1996", Journal of the World Energy Council, July 1997b
- **Kaya, Y.**; "Impact of carbon dioxide emissions on GNP growth : Interpretation of proposed scenarios", Response Strategies Working Group, IPCC, May 1989
- La Rovere, E.L. ; Santos, M.A.; Almeida, M.A.; Schechtman, R.; Rosa, L.P.; Legey, L.F.**; Analysis of Abatement Costing Issues and Preparation of a Methodology to Undertake National Greenhouse Gas Abatement Cost Studies. Country Study : Brazil, UNEP/CCEE, Roskilde, May 1993.
- La Rovere, E.L.**; "Carbon Sinks and Adjustment Policies in Developing Countries", Proceedings of the International Symposium on the Prospects for Integrated Environmental Assessment : Lessons learnt from the case of Climate Change, Toulouse, France, 24-26 October 1996.
- [**La Rovere, E.L. ; Schaeffer, R.; Americano, B. B.; Machado, G. V.**; Social and Environmental Benefits from PROCEL and Scenarios for their Future Evolution, Activities Report, Eletrobrás, May 1997 (*in Portuguese*).
- MME (Brazilian Ministry of Mines and Energy)**; National Energy Balance, 1996
- OECD/IEA (Organization for Economic Cooperation and Development / International Energy Agency)**; "Climate Change Policy Initiatives - 1995/96 Update", volume II, "Selected Non-IEA Countries", OECD/IEA, Paris,1996
- OLADE (Latinamerican Organization for Energy Development)**; "Energia y Desarrollo Sustentable : Una Propuesta Conceptual para America Latina y el Caribe", Quito, Ecuador, November 1996
- Reis, E.**, "The Contribution of Brazilian Amazon Deforestation to Carbon Dioxide

Emissions", IPEA, Rio de Janeiro, 1993

-**Rocha, H.R.R.**; "CO₂ Flux over the Brazilian Tropical Rain Forest and Cerrado", Greenhouse Gas Emissions under Developing Countries Point of View, COPPE/UFRJ, February 1996, p.68-77.

-**Rosa L. P., Tolmasquim M., Schaeffer R. , La Rovere E.L., and Schechtman R.**, Energy Conservation Project Report, COPPETEC- PROCEL, 1996

- **Rosa, L.P.; La Rovere, E.L.**; Overview of Latin American Technology Development for Avoiding Greenhouse Gases Emissions and for Mitigating Climate Change, Latin American Regional Workshop on Technological Choices and New Opportunities for Sustainable Development within the Implementation of the United Nations Framework Convention on Climate Change in Latin America, COPPE/UFRJ, Rio de Janeiro, 3-5 October, 1997.