SUMMARY

INTRODUCTION

The stated objective of the United Nations Framework Convention on Climate Change (UNFCCC) signed by 155 countries in Rio de Janeiro, Brazil, in 1992 is to bring about “stabilization of greenhouse-gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system” (Article 2). As guiding principles for accomplishing this aim the Convention provides among other things that all Parties “should protect the climatic system for the benefit of present and future generations of humanity on the basis of equity and in accordance with their common but differentiated responsibilities and respective capabilities,” and that they “should take preventive measures to anticipate, prevent or minimize the causes of climate change and mitigate its adverse effects” (Article 3).

The Convention was adopted by Colombia on May 9, 1992 and approved by the Colombian Congress in Law 164 of 1995. The Supreme Court of Justice passed a favorable judgement on the constitutional nature of the Convention, which was ratified on March 22, 1995 and came into force for Colombia on June 20, 1995. Colombia, as a Non-Annex 1 country, is bound by the following general commitments laid down for all nations signatories to the Convention:

- To develop, periodically update, publish and submit to the Conference of the Parties national inventories of anthropogenic emissions of all greenhouse gases not controlled by the Montreal Protocol;
- To use IPCC methodology in preparing the inventory; and
- To draw up, implement, publish and regularly update national programs containing measures for mitigating climate change through treatment of anthropogenic emissions.

The commitments of the industrialized countries listed in Annex 1 include the provision of financial assistance to the developing countries for preparing their national communications and the transfer of technologies to such countries to enable them to implement their emission-reduction programs. In this context, the *Inventory of Greenhouse Gases - Colombia 1990* [1] was prepared during 1995 and 1996 by the Colombian Academy of Exact, Physical and Natural Sciences (the Academy) with support from the German Technical Cooperation Agency (GTZ) and collaboration from the Environment Ministry. As a follow-up to the *Inventory* a second study, *Options for Reducing Greenhouse-Gas Emissions in Colombia 1998-2010*, was undertaken by the Academy in 1998, again with support from GTZ. Methodological guidelines developed by UNEP [2,3] and the US Country Studies Programme [4] were followed in preparing the new study. The reason for adopting internationally accepted methodologies was to facilitate comparison between findings from different countries. This Executive Summary presents findings for the case of Colombia and proposes some general criteria for drawing up a Colombian National Plan for Reducing Greenhouse-Gas Emissions[a].

BASE CASE 1998-2010

The activities affecting greenhouse-gas emissions may be divided into two sectors: energy and non-energy. The base case describes the expected evolutions of both sectors for the period under study, on the basis of a number of given development prospects for the country.

For the energy sector's base case we took into account the figures and findings of analyses conducted by the Mining and Energy Planning Unit (UPME) of the Ministry of Mines and Energy. UPME is responsible for generating energy plans, programs and policies, compiling historical data, and making projections of energy demand for the short, medium and long term. By complementary use of econometric and analytical models, UPME has estimated final energy demand by taking into account possible substitutions in the residential, industrial and transport sectors, in view of expected diversification in the types of energy available in Colombia[5, 6, 7].

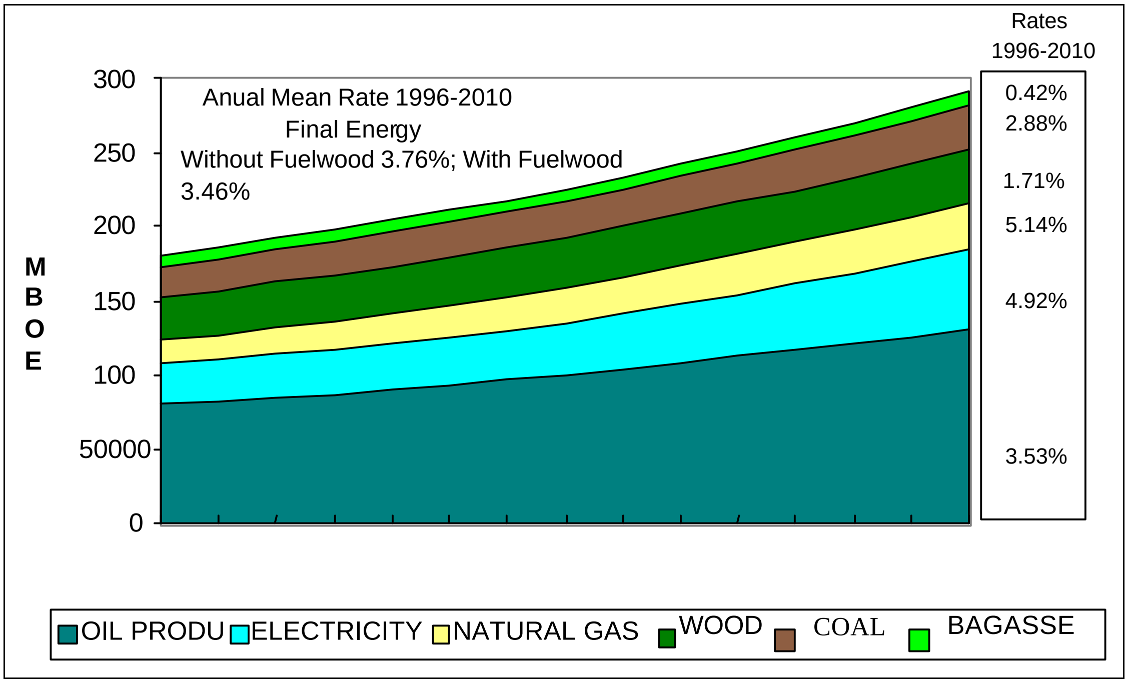
To make projections of the national system's energy needs, UPME employed the ENPEP [8] analytical model, which gets a feedback of econometric projections. The model uses a non-linear general equilibrium approach to determine the balance of energy supply and demand, and takes into account all processes, programmes or actions designed to bring about energy substitution, efficient use of energy, and use of efficient equipment.

By employing these two types of model in a complementary fashion, it is possible to use historical data regarding the evolution of demand to determine its historical tendency and modify it by incorporating the expected effects of applying different actions. Such actions include programmes for promoting rational energy use, energy substitution (for example, natural gas rather than electricity, for cooking), or technological changes in equipment. This methodology was therefore very appropriate for the specific aims of the mitigation study here presented. It also made it possible to estimate final energy demand without completely disaggregating economic subsectors or energy use.

[a] The formulation and implementation of plans of this nature is the responsibility of the Ministries of the Environment, of Mines and Energy, of Agriculture, and of Development, as well as the National Planning Department, among others. Consequently, the Academy's proposal is presented not in place of action by Colombian state institutions but as a contribution by the country's scientific and technical community to discussions on an issue of such importance.

Figure 1 shows the expected growth in demand in the coming years, up to 2010.

Figure 1 Final Energy Demand Base Case 1996-2010



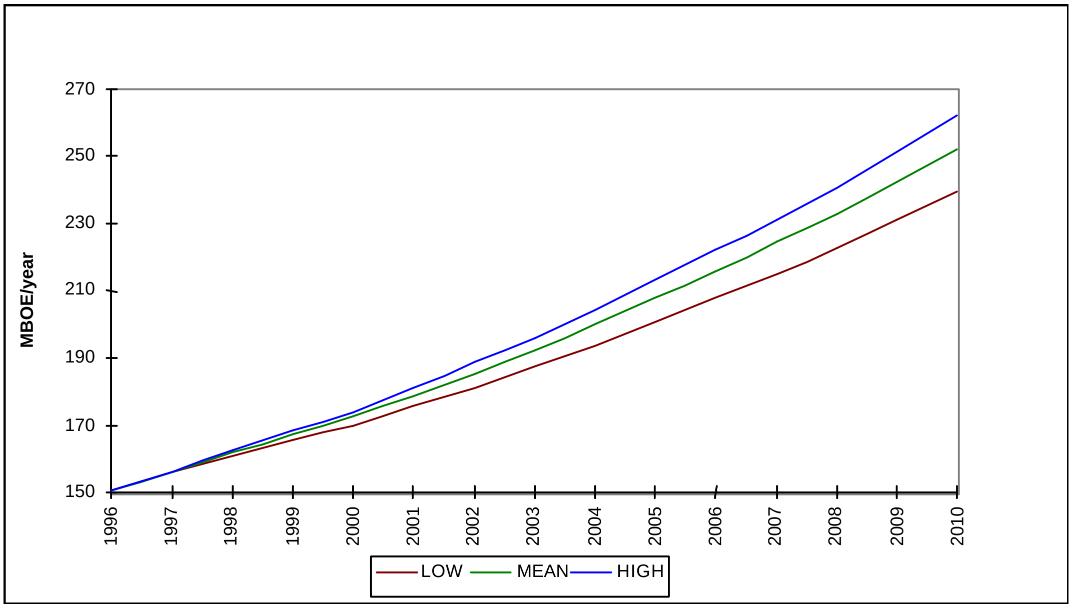
Source: Plan Energético Nacional 1997 - 2010, UPME, 1997

By the year 2010 the country will be consuming 252.6 MBOE (excluding fuelwood), about 100 million less than today. If we add fuelwood, consumption starts at 180 MBOE and rises to 290 MBOE. Figure 2 presents the projected range of final energy demand (excluding fuelwood) for the base case, before GDP scenario changes. The annual increase expected over the whole period under study (1996-2010) ranges between 4.03% and 3.35%.

In 1996 UPME published an update of its *Generation Expansion Plan - Transmission* [6]. This plan presented, to the various agents in the electric sector, four development strategies designed for the short, medium and long term.

For the long term (2001-2010) various combinations of gas, coal and water power plants are considered. UPME proposed four different strategies, identified as LP-1, LP-2, LP-3, and LP-4. LP-4 is the strategy with the largest component of coal-fired thermoelectric generation and is therefore the one considered in the various emission-reduction analyses conducted in this study, because it is the scenario with the greatest amount of greenhouse-gas emissions.

Figure 2. Projected range of final energy demand



Source: Plan Energético Nacional 1997 - 2010, UPME, 1997

The non-energy sector considered in this study consists of the forestry and farming subsectors. The main assumptions with regard to forestry are that deforestation will proceed at a rate of 200,000 hectares per year up until 2010. In 1995 the area of natural forests under exploitation was about 35,000 hectares, producing an estimated volume of 1,969,216 cubic meters of timber, of which 1,386,772 cubic metres were legally registered and the remaining 582,444 cubic metres evaded state control [9]. It is assumed that this national consumption tendency will continue for the next 10 years with a 4% annual growth.

Accumulated reforested area up until 1995 amounted to 270,000 hectares[9]. Reforestation for commercial purposes over the next 10 years is estimated at 332,000 hectares [10], and will be entirely carried out by the private sector. A further 231,000 hectares are expected to be planted as protective reforestation by Autonomous Regional Corporations and Sustainable Development Corporations, with support from the Environment Ministry and loans from the Inter-American Development Band and the World Bank.

In addition, agroforestry (forest-plantation and forest-grazing systems) is projected to cover an area of 195,000 hectares. Much of this activity will be carried out in the coffee-growing region, where an estimated 300,000 hectares are to be switched from coffee crops to other uses, including some 175,000 hectares to be converted to agroforestry systems.

As regards the farming sector, the following assumptions have been made: For crop farming, particularly the crops included in the Greenhouse-Gas Inventory, such as rice, maize, sugar cane, African palm and cotton, very little reactivation of production is estimated for either the short term (1996-2002) or the medium term (2002-2008). For example, it is assumed that the total area under rice (some 400,000 hectares) will not vary markedly but undergo fluctuations of no more than 5% and possibly a small variation in composition, the proportions of continually flooded and intermittently flooded rice paddies changing from 65% : 35% (reported in the 1990 Greenhouse-Gas Inventory) to around 60% : 40%[1].

For stockbreeding, the assumptions are as follows: Population growth for cattle will be between 2% and 2.5% a year, for poultry a uniform 2.5% a year, and for other animals referred to in the Inventory between 1 and 2% a year. The stockbreeding sector as a whole will grow at the same rate as in the previous period: 2.5% a year.
The burning of farm waste in the field is still considered to be seldom practiced in Colombia and hence a negligible quantity in counting the amounts of greenhouse emissions. Savanna burning is traditional practice and as such estimated to contribute to greenhouse-gas emissions in much the same way as before, since the total savanna area subjected to burning in Colombia will continue to be the same as reported in the Greenhouse-Gas Inventory with 1990 as base year. This means that no growth is taken into account for savanna burning.

BASE-CASE EMISSIONS

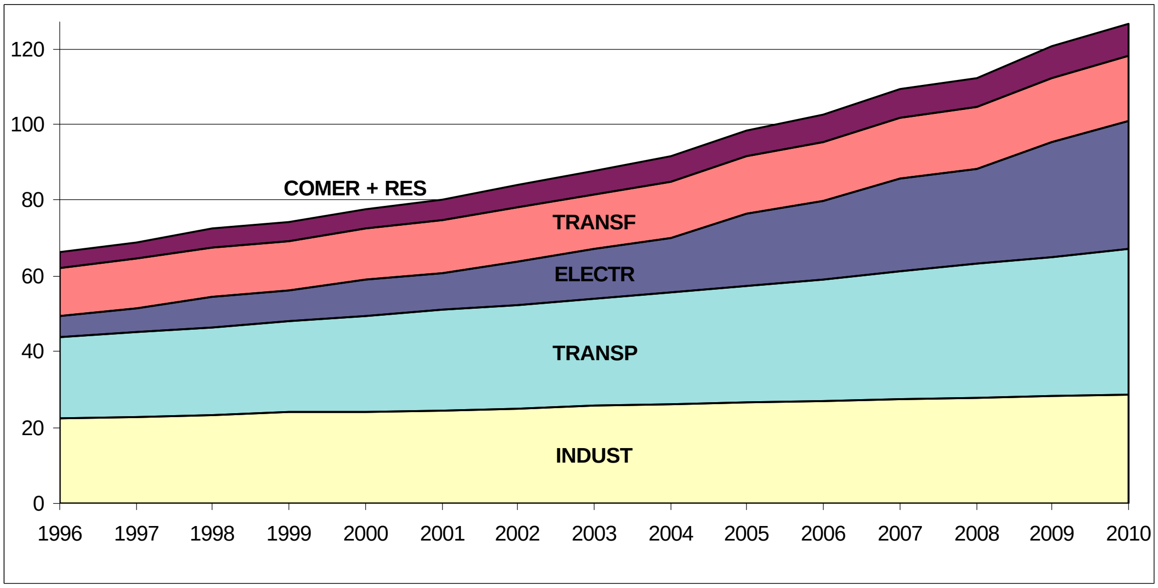
In estimating emissions for the base case, the energy sector and the non-energy sector were considered separately.

Energy-sector emissions

For the energy sector, projections generated by the ENPEP model were used in the IMPACTS module to calculate emissions, with emission factors depending on the type of technology. These factors were taken from the IPCC methodology[11] and from the AP-42 standards[12]. For the non-energy sector, carbon-dioxide and methane emissions were estimated on the basis of the assumptions described and using the methodology of the Inventory.

Carbon dioxide: Figure 3 shows total CO_2 emissions for different sectors of the economy. Total emissions amounted to 66.4 Mt in 1996. They show a tendency to grow and are expected to rise to more than 120 Mt by 2010, which means that by the end of the next decade CO_2 emissions will be double the level they registered in 1990.

Figure 3.CO_2 Emissions by Economic Sector (Mt/year)



The largest increase in emissions is expected to come from the electric sector. In 1996 the electric sector was responsible for 8% of total CO_2 emissions, but by 2002 this share will be up to 14% and by 2008 as high as 22%.

Although emissions from the transport and industrial sectors will increase, their percentage shares of total emissions are expected to fall, owing to the electric sector's large increase. In 1996 their shares were 32% and 34% respectively, but by 2008 they will drop to 31% and 25% respectively. It is important to point out that the industrial sector's share of total emissions will fall from 34% to 25% mainly because of the penetration of natural gas in this sector. The percentage share of the residential-cum- commercial sector does not vary much over the period under study.

Methane: In the energy sector methane is discharged as fugitive emissions in coal mining, oil exploitation and natural-gas management; it is also produced by combustion in the different sectors of the economy (referred to as 'other energy').

Out of total methane emissions in 1996, 146,000 tonnes, 75% consisted of fugitive emissions, while in 2010 their share will rise to 82% because of expansion in coal mining and oil exploitation.

Methane emissions from combustion (other energy) were mainly produced by the residential-cum-commercial sector, because of the use of fuelwood; but this sector's share shows a tendency to drop from 67% of combustion emissions in 1996 to 59% in 2010.

Emission of other greenhouse gases like CO, NOx, N_2O and NMVOC were also evaluated (see full report).

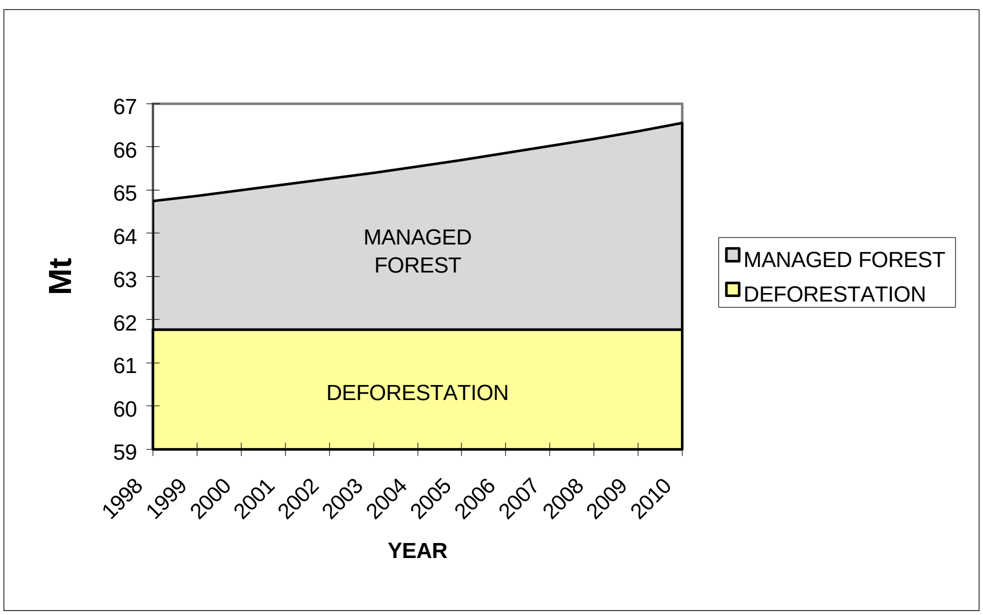
Non-energy sector emissions

Forestry subsector

Emissions in the forestry subsector come from logging and burning in deforested woods, and from the industrial use of timber mostly logged in natural forests. Figure 4 shows the expected evolution of carbon-dioxide emissions under base-case assumptions.

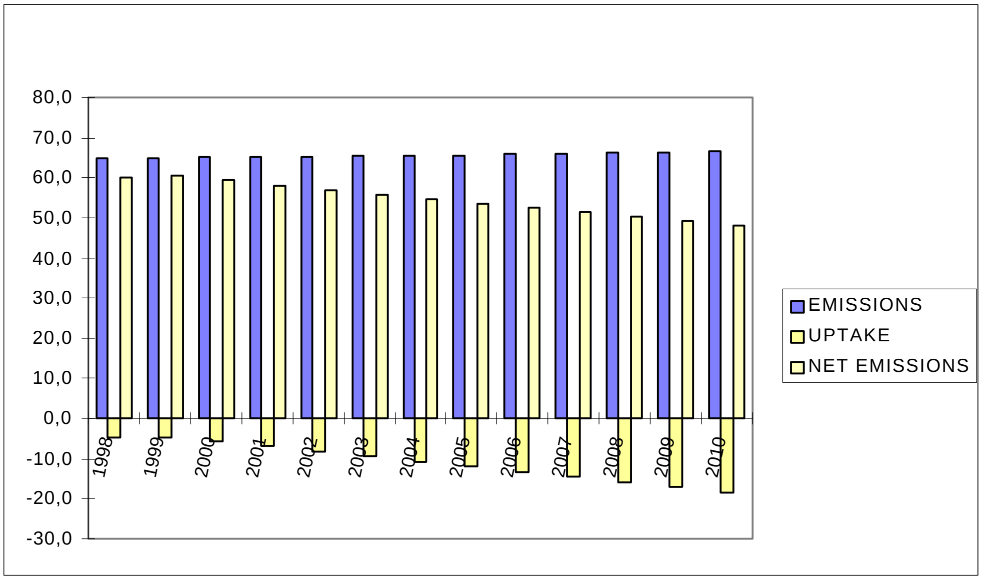
The uptake of carbon dioxide in this subsector results mainly from protective and commercial reforestation, and also from regeneration of natural forests exploited under licence. According to the government plans referred to as making up the base scenario, such reforestation activity is expected to cover 76,000 hectares a year starting from 1998. Figure 10 illustrates the evolution of CO_2 uptake over the next ten years.

Figure 4. CO_2 emissions in forestry sector – base case (Mt/year)



Carbon-dioxide uptake reduces the subsector's net CO_2 emissions from 60.2 Mt to 48.2 Mt by the year 2010 (Figure 5).

Figure 5. Evolution of $C0_2$ Net Emissions (Emissions and uptake) (Mt / year)



Farming subsector

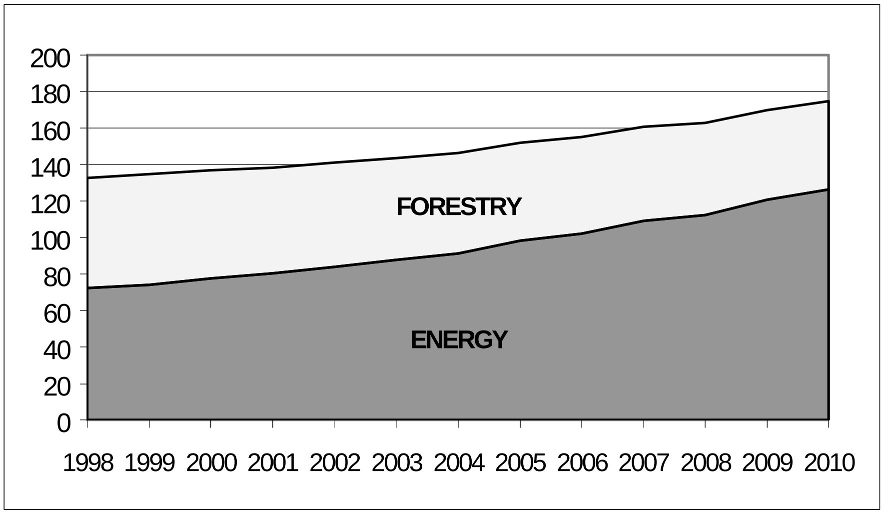
Emissions from the farming subsector essentially consist of methane and nitrous oxide, and to a lesser extent of carbon monoxide and nitrogen oxides. Carbon-dioxide emissions are nil, because the IPCC methodology considers that the amount produced by biomass burning is exactly balanced by uptake resulting from natural regrowth of vegetation.

Methane emissions from farming are estimated, under base-case assumptions, at 1.6 Mt in 1996, 1.8 Mt by 2002, and 2.0 Mt by 2008. Enteric fermentation among dairy and meat cattle is the chief source of methane emission, representing 84.5% of the total in 1996 and 87.6% by 2008.

Net carbon-dioxide emissions

Figure 6 shows the evolution of total net carbon-dioxide emissions in Colombia from the energy sector and the non-energy (in this case forestry) sector, over the period 1997-2010.

Figure 6. Total CO2 Emissions from Energy and Forestry Sectors Case Base 1998-2010 (Mt/year)

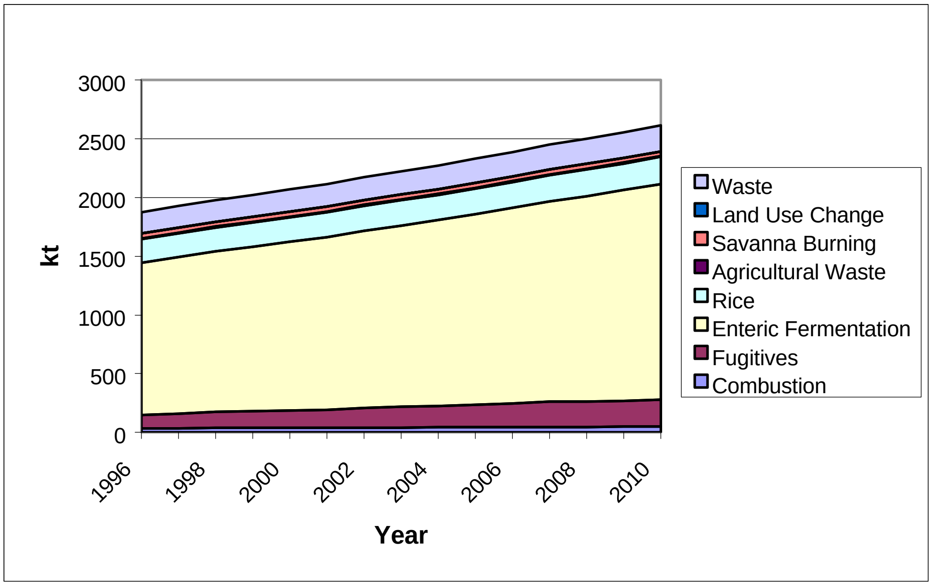


Carbon-dioxide emissions in 1990 stood at 167 Mt, with the energy sector accounting for about 31% (52.3 Mt) of the total and the forestry sector (logging and forest burning) for the rest (111.3 Mt). From 1990 to 1998 the energy sector's expansion also increased its CO_2 emissions from 52 Mt to 72 Mt. In contrast, the forestry sector's CO_2 emissions plunged from 111 Mt in 1990 to 60 Mt in 1998, as a result of tighter controls and policy changes at the national level in this regard. Over the period 1998-2010 shown in Figure 12, CO_2 emissions continue to fall in the forestry sector, down to 48 Mt by 2010, and to rise in the energy sector up to 126 Mt. Thus total CO_2 emission in 2010 (174 Mt) compared with the 1990 total (167 Mt) shows an increase of barely 8 Mt in 20 years. This might seem an over-optimistic scenario but it is not so actually, because the deforestation figure used in the 1990 Inventory, following the IPCC methodology guidelines, was the average rate for the period 1970-1990, whereas in fact deforestation decreased steadily from 1970 on, to the extent that by 1990 the rate was much lower than the average. This is why there seems to be a leap between 1990 and later years: in 1998 the rate of deforestation was assumed to be 200,000 hectares/year, far below the 367,000 hectares/year rate that was taken as the average for 1970-1990. This makes it appear as though total emissions hardly increased in 20 years, with no mitigation measures other than logging control being taken into account. The energy sector's carbon-dioxide emissions soar from 52 Mt in 1990 to 126 Mt by 2010, the increase being offset by a reduction in the rate of deforestation over the same period.

Total methane emissions

Figure 7 shows the evolution of total methane emission in Colombia from each type of source over the period 1996-2010.

Figure 7. Total CH_4 Emissions by Source Base Case 1996 – 2010 (kt/year)



The largest discharge is from enteric fermentation, which maintains its 70% share of the total up to the year 2010. As in the 1990 Inventory, digestion in dairy and meat cattle accounts for 95% of methane emissions from this source. Other sources, in order of importance, are the energy sector with fugitive methane emissions; sanitary landfills with emissions from anaerobic decomposition of waste matter, and flooded rice paddies. In the base scenario, total methane emission is projected to show a small annual increase of about 2.5%.

EMISSIONS REDUCTION OPTIONS

The option for reducing emissions consists in replacing present technology by one of the new technologies[a] or introducing new technologies instead of traditional ones. Each of these new technologies is evaluated by conducting a technical, economic and environmental analysis, in which comparisons are made in economic and

[a] These new technologies use energy in a more efficient and rational manner and hence reduce greenhouse-gas emissions either because they use less energy or because less amounts of residual matter is produced in combustion.

environmental terms between two technological options providing the same amount of energy or the same service with the same degree of reliability.

Costing[2,3] considers the project's useful life, investments costs, O&M, and the cost of fuel (free of taxes and subsidies) to be used for each one of the options (costs in US dollars). All these costs involve a net present value (NPV) annuality, and the total annual cost is estimated for both the reference option (to be replaced or traditional option) and the emission-reducing option. This net present value is estimated on the basis of the project's useful life and an annual discount rate of 10%.

The two options are compared in economic terms by calculating the cost increment as the difference between the costs of the reducing option and those of the reference option. A negative increment means that the proposed reducing option is more advantageous in economic terms than the reference option.

Likewise, greenhouse-gas emissions produced by the reference option and the reducing option are estimated. Emissions of carbon dioxide, nitrous oxide, and methane are estimated in tonnes per year, using emission factors from the 1996 IPCC methodology and fuel consumption for each option. All emissions are then reduced to CO_2-equivalent emission. The two sets of emission are compared to calculate the reduction in emissions, by subtracting the reducing-option's emission from the reference-option's. A positive result means that the new option does reduce the discharge of greenhouse gases into the atmosphere. A cost/benefit indicator for assessing the worth of an emission-reducing option is the ratio between the cost increment for the reducing option, and the reduction in discharge in terms of CO_2-equivalent emission. The unit for this indicator is dollars per tonne of CO_2 equivalent.

Mitigation options for the non-energy sector are evaluated in a similar way. In this case the reference option is to leave things as they are, and mitigation options involve upgrading or expanding carbon-dioxide sinks (afforestation and reforestation) or protecting present deposits (protection of natural forests, sustainable development programmes). Negative-ratio options may also be found in this case.

For Colombia, each technology's penetration scenario has been built by taking into account studies determining the technology's potential (e.g., cogeneration[13,14]), potential equipment demand (e.g. illumination [15]), etc. The selection of options in the field of forestry was based on knowledge obtained from over 15 years' successful experience in reforestation and forest-grazing systems established in regions offering development possibilities.

To analyze emission-reducing options in the energy sector it was necessary to prepare an energy capacity and generation mix. The purpose of the energy mix was to estimate average costs of future energy-generating equipment and the emissions resulting from expansion of the generating system in the period 2000-2010. Table 1 shows the structure of the country's electricity generation capacity up to 1996, expansions carried out in 1996-2000, and projected expansions under the LP1 to LP4 scenarios, together with each scenario's total by 2010. As can be clearly seen, power generation in Colombia is shifting from an expensive hydro-based (75.6%) but low-emission system in 1996, to a less capital-intensive but higher-emission system by 2010 (51.9% hydro, 48.1% gas and coal).

Table 1. Structure Of Energy Generation Capacity

POWER	**Hydro**	**Coal**	**Gas**	**TOTAL**	
Until 1996	8017	918	1666	10601 MW	**Effective**
1996-2000	732	150	1783	2665 MW	**LP1**
2001-2010	2531	450	3607	6588 MW	**LP1**
TOTAL	11280	1518	7056	19854 MW	**LP1**
2001-2010	2864	1200	2529		**LP2**
TOTAL	11613	2268	5978	19859	
2001-2010	2014	900	3342		**LP3**
TOTAL	10763	1968	6791	19522	
2001-2010	1361	1600	3236	6197	**LP4**
TOTAL	10110	2668	6685	19463	

Percentage Share

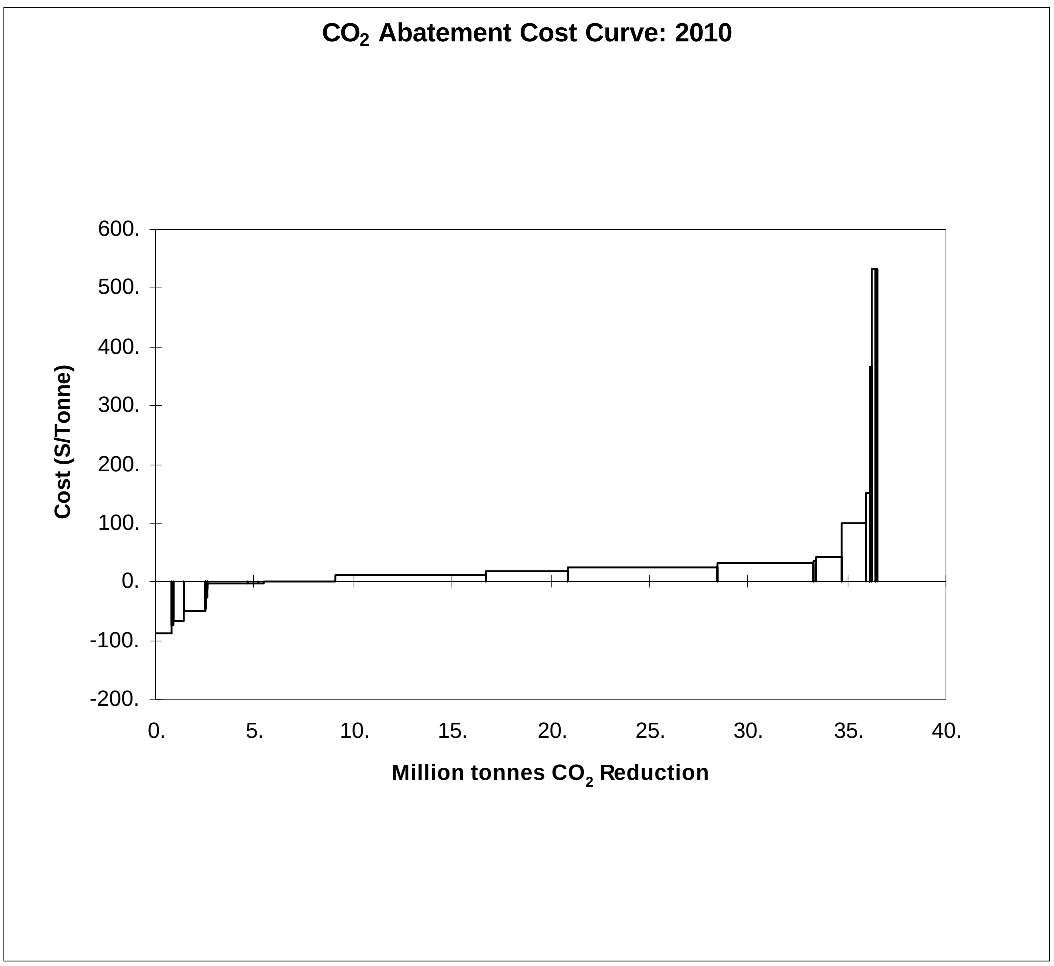
	Hydro	**Coal**	**Gas**	**TOTAL**	**Scenario**
Until 1996	75,6%	8,7%	15,7%	100,0%	
1996-2000	66,0%	8,1%	26,0%	100,0%	
Final 2010	56,8%	7,6%	35,5%	100,0%	**LP1**
Final 2010	58,5%	11,4%	30,1%	100,0%	**LP2**
Final 2010	55,1%	10,1%	34,8%	100,0%	**LP3**
Final 2010	51,9%	13,7%	34,3%	100,0%	**LP4**

The options for reducing emissions in energy generation must be compared on the basis of the respective costs and emissions of the chosen scenario, LP4. For Colombia, to diversify its energy basket is very convenient. Coal is for Colombia an important fuel due to the existence of huge resources and coal energy based generation adds reliability to the whole energy system, due to the uncertaintes of its hydrological resources and the operative problems of the natural gas fired power plants. In spite of LP4 scenario is emissions intensive, is very convenient because is a potential source of employment and NPV of the coal plant investment and cost of fuel is low.

Of the energy to be generated by the LP4, 57.2% will come from gas-fired plants, 27% from coal-fired plants, and only 15.7% from hydroelectric stations. The immediate consequence will be a decrease in capital costs from $1,300 per installed kilowatt in a wholly hydroelectric system, to $836 per installed kilowatt in the LP4 mix but with an increase in emissions.

On the basis of the chosen technologies and their penetration to the year 2010, a scenario of 24 emission-reducing options was developed, with assistance from Riso and using UNEP's GAMCO software[16]. These options are arranged according to their cost/benefit index. Table 2 summarizes the findings for the emission-reducing scenario built for Colombia, and Figure 8 presents the corresponding abatement-cost curve.

Figure 8. Abatement Cost Curve For Reducing Greenhouse-Gas Emissions In Colombia Up To The Year 2010



In this scenario, the overall potential reduction in emissions by the year 2010 is 36.5 Mt of carbon dioxide. Ten of the 24 options have a negative cost-benefit ratio. This preliminary assesment has not considered the transactional and risk costs. Forestry options are prominent among the fourteen, for they produce most of the reduction in emissions: 24 Mt by 2010, representing over 66% of the total. The remaining 34% of potential reductions is produced by the energy sector.

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Tabla 2. Colombia's Greenhouse-Gas Mitigation Scenario

Reduction option	$/ton$CO_2$	Unit Type	Emission reduction t CO2/unit	Units penetrating in 2010	Reduction in 2010 Mill.t/year	Cumulative Reduc. 2010 Mill. t/year	Reduction in 2010
Cogeneration (1 MW)	-87	MW	2,061	400	0.82	0.82	0.47%
Timer to DWH	-73	DWH with timer	1	200,000	0.11	0.93	0.53%
Efficient lighting	-69	Bulb	0.05	10,000,000	0.46	1.40	0.80%
Ethanol blend	-51	Plant	111,923	10	1.12	2.52	1.44%
Efficient motors	-48	kW	1.4	14,000	0.02	2.54	1.45%
Hydro Vs. CC	-26	MW	52	1,361	0.07	2.61	1.49%
Methane from sewage	-13	Plant	966	10	0.01	2.62	1.50%
Efficient boilers	-2	1 Boiler	4,164	500	2.08	4.70	2.69%
Gastrucks	-2	1 Small truck	16	26,910	0.43	5.12	2.93%
Gasbuses	-2	1 Bus	16	22,425	0.35	5.48	3.14%
Solarheater	0	Solarheater	2.1	100,000	0.21	5.69	3.26%
Biogas from landfills	1	Landfill	689,816	5	3.45	9.14	5.23%
Eucalipto Afforestation	11	14 ha	252	30,000	7.56	16.70	9.56%
Protector reforestation	18	ha	18	231,000	4.20	20.90	11.97%
Pine Afforestation	25	14 ha	252	30,000	7.56	28.46	16.30%
TECA- Afforestation	31	14 ha	161	30,000	4.84	33.30	19.07%
Wind turbines	36	kW	1.5	100,000	0.15	33.45	19.15%
Minihydro power	43	kW	6.2	200,000	1.24	34.69	19.87%
Microhydro	101	kW	1.1	1,000	1.24	35.94	20.58%
Gastaxies	149	1 Taxi	3.5	65,665	0.23	36.17	20.71%
Biogas for rural households	168	Digester	0.4	5,000	0.00	36.17	20.71%
Close Cicle	365	MW	73	1,500	0.11	36.28	20.78%
Combined Cicle	531	MW	75	3,000	0.22	36.51	20.90%
PV electricity 1	532	kW	1.1	20,000	0.02	36.53	20.92%

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Total Emis in 2010: 174.63 Million tonne

The other options have a positive ratio and involve “alternative energy sources” , new energy technologies and “reforestation options.”

Reforestation options have a very high emission-reducing potential of 24 Mt/year; and there is thought of involving 90,000 families.

The energy sector’s forteen emission-reducing options have a potential of barely 12.5 Mt/year.

MACROECONOMIC IMPACT OF EMISSION-REDUCING OPTIONS

Colombia is a middle-income country whose long-term economic performance has been average in the context of Latin American, but in recent years there have been signs of economic slowdown. Annual economic growth fell from more than 5.0% during 1993-1995 to only 2.8% in 1998 and is expected to drop further to 2.0% in 1999. The economy is expected to show an upturn by the year 2000, with growth rates rising above 5.0% by the year 2002. During the nineties, the primary sector’s growth has decreased significantly and the industrial sector has failed to show the expected dynamism, but the tertiary sector has grown.

Unemployment has risen sharply in Colombia in the nineties, up to 15.1% in September 1998, mostly affecting the less-educated and the underprivileged. The labour situation is not promising at the moment because of the budget crisis, the dynamic sectors’ inability to absorb the unemployed, and certain structural features of the labour market.

The nineties have continued to see a marked inequality in income distribution (Gini index: 0.47), a great lack of equity and alarming levels of poverty: 55% of the population is under the poverty line, with 20% even under the line of indigence.
The balance-of-payments current account has deteriorated, going from a surplus of 5.5% of GDP in 1991 to a deficit of 6.6% in 1998. The aim is to bring the deficit down to 3.5% by the year 2002. Deterioration has been caused by a growing trade deficit, lower net transfers, and an increasingly negative service balance since 1995. The trade balance fell from a surplus of 7.0% of GDP in 1991 to a deficit of 3.8% in 1998. The deficit is expected to be reduced to 0.2% of GDP by the year 2002. The capital account’s mounting surplus over 1992-1996 rose to 8.3% of GDP but dropped down to 4.8% in 1997-1998. It will go up again in 1999, to 6.2% of GDP, then down once more, to 4.0% by 2002.

The budget deficit, too, has deepened in the nineties. The problem is largely attributable to the central government, in particular to its current spending, especially transfers and personal services.

The greenhouse-gas programme under study envisages 24 options, whose costs are summarized in Table 3. The total amounts to $17.344 Millions, whereas the reference option costs only $1,623 Millions. The difference is explained by the fact that most of the projects are new ones and mainly in the nature of extensive reforestation projects, costing in all $12.139 Millions, or 69.9% of the total. The other options are for introducing new technologies, as against "leaving things as they are" ("business as usual" - reference cost 0). The proposed new-technology options involve an investment increment of $5.204 Millions over the "business as usual" option. It is worth noting that many of the options have a high domestic content, particularly the mitigation options based on reforestation by planting teak (*Tectona grandis*), pine or eucalyptus, and protective reforestation. A first estimation indicates that these projects would generate some 186,600 direct jobs over the periods under study, with a 100% domestic content. The new-technology projects have little domestic content and do not create many direct jobs compared with the forestry options.

Implementation of all the projects would require an annual expenditure estimated at around 1.7% of GDP.

Execution of these projects—essentially the job-creating forestry projects—should be considered not only in the context of environmental concerns, but also as an important means of achieving the aims of the plan called *Changes For Building Peace*.

Table 3. Costs And Impacts Of Mitigation Options

Reduction option	Units penetrating in 2010	Unit Type	Total Investment M US$	Total Reference M US$	National Share %	Imported Share %
Cogeneration (1 MW)	400	Mw	212	73	30	70
Timer to DWH	200,000	DWH with timer	8	0	25	75
Efficient lighting	10	1 million Bulbs	80	40	100	0
Ethanol blend	10	Plant	400	0		
Efficient motors	14,000	kW	6	0	90	10
Hydro Vs. CC	1,361	MW	2	1		
Efficient boilers	500	tonnes	49	0	10	90
Gastrucks	26,910	1 small truck	60	0		
Gasbuses	22,425	1 bus	50	0		
Methane from sewage	10	plant	1	0	30	70
Biogas from landfills	5	Landfill	88	0	30	70
Solarheater	100,000	Solarheater	100	15	70	30
Eucalipto Afforestation	30,000	14 ha	3,371	0	100	0
Protector reforestation	231,000	1 ha=	711	0	100	
Pine Afforestation	30,000	14 ha	3,575	0	100	0
TECA- Afforestation	30,000	14 ha	4,482	0	100	0
Wind turbines	100,000	kW	140	53	30	70
Minihydro power	200,000	kW	1,386	120	90	10
Microhydro	1,000	kW	3	2	90	10
Gastaxies	65,665	1 taxi	146	0		
Biogas for rural households	5,000	digesters	13	0	100	0
Close Cicle	1,500	MW	340	0	10	90
Combined Cicle	3,000	MW	1,940	1260	10	90
PV electricity 1	20,000	kW	180	60	50	50
24			17,344	1623		

The projects are fully consistent with the government's environmental intentions, for example: the forestry plan for greater restoration and conservation of strategic eco-regions so as to improve the quality of life of the population; clean production; and upgrading the quality of urban life. And even more important within the Colombia context, there is also the fact that several of the identified options for mitigating greenhouse-gas emissions could contribute to the peace process through investment and job creation in zones of social conflict, with the further result of relieving the problem of migration to urban areas.

Consideration is currently being given to creating a carbon exchange through which the advanced countries may buy greenhouse-gas reduction to meet their international commitments regarding the environment. Colombia should consider making effective use of this mechanism to attract foreign investment that will contribute to development and to a higher standard of living in the more marginalized areas and also help to meet the global objective of environmental protection.

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