Greenhouse-Gas Emissions in Colombia 1998-2010

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GHG EMISSIONS IN COLOMBIA 1998-2010

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Abstract

The Greenhouse Gas Emissions baseline scenario 1998-2010 was developed from the energy and no-energy sector projections. This study considered the same greenhouse gases as the 1990 Inventory. One of the major findings is the increase in the participation share of the energy sector from 31% in 1990 up to 72% in 2010, while the non-energy sector decrease its share from 69% to 28% in the same period. The total emissions increase from 167 Mt/year in 1990 to 174 Mt/year in 2010, an increase of only 4%.

Key words: Greenhouse gas emissions, Colombia, Projections, Inventory

INTRODUCTION

The stated objective of the United Nations Framework Convention on Climate Change (the Convention) 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:

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- 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.

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 paper presents the main findings of the GHG Emission projections for the Base Case Colombia 1998-2010

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.

UPME took as its base scenario, from among the different combinations discussed by it (charges, fuel switches, etc.), a scenario of "not doing anything about the environment," that is to say, the country's energy path if current policies and demand tendencies were maintained. This scenario is built on the following assumptions:

- The macroeconomic scenario is initially based on the National Planning Department's official scenario for 1997-2000. From 2001 on GDP is assumed to grow at an average annual rate of 4.5%, which is close to Colombia's average historical long-term growth rate (see Table 1):

Table 1. Gdp Growth Rates Used In Scenarios For Projecting Energy Demand

1997	1998	1999	2000	2001-2010	Mean
3.6%	3.8%	5.11%	4.7%	4.5%	4.44%

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

- Increase in residential-sector charges is governed by Law 287, which provides that the residential-sector charges shall rise to 86.4% of the reference cost by the year 2000 and thereafter be kept constant in real terms. Gas prices are linked to wellhead ceilings established in resolutions by the Energy and Gas Regulatory Commission (CREG) and to gas transport and distribution costs. Table 2 shows real increments in residential-sector charges:

Table 2. Tariff Increases Used In Scenarios For Projecting Energy Demand

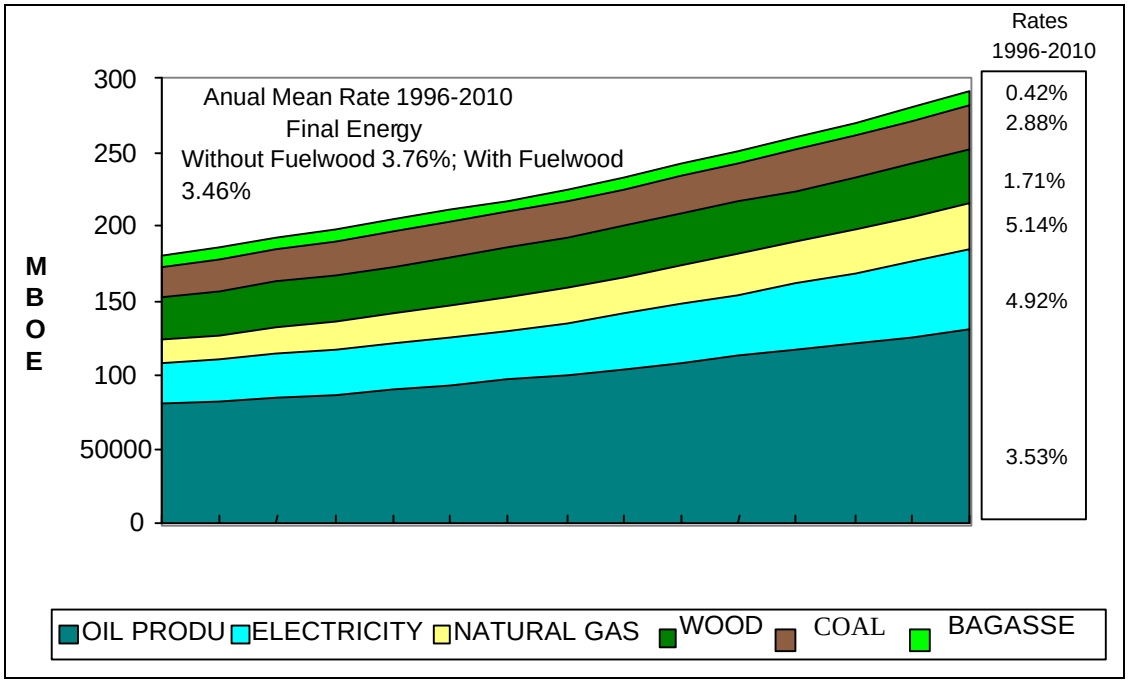
1997	1998	1999	2000	2001	2002-2010
1.9%	0.0%	12.3%	11.2%	5.3%	0.0%

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

- For the urban-residential sector the cost of credit is assumed to be 4 points above the consumer price index (annual inflation), with five-year funding periods for the first scenario.
- As regards street lighting, econometric projections are used for this demand.
- No increment at all is considered for refinancing capacity.
- The electric-energy expansion strategy chosen for the base case is LP-1[9]. Over the short term (1997-2000) capacity expansion is expected to consist of 1783 MW generated by gas, 150 MW by coal, and 732 MW by hydropower. Over the long term (2001-2010) installed capacity would be further increased by 3607 MW generated by gas, 450 MW by coal, and 2531 MW by hydropower.

This is the most realistic and likely scenario because planned expansion in this sector is being strictly carried out for some years now. These development plans are constantly reviewed and updated. Figure 1 shows expected growth in demand in the coming years, up to 2010.

Figure 1 Final Energy Demand Base Case 1996-2010



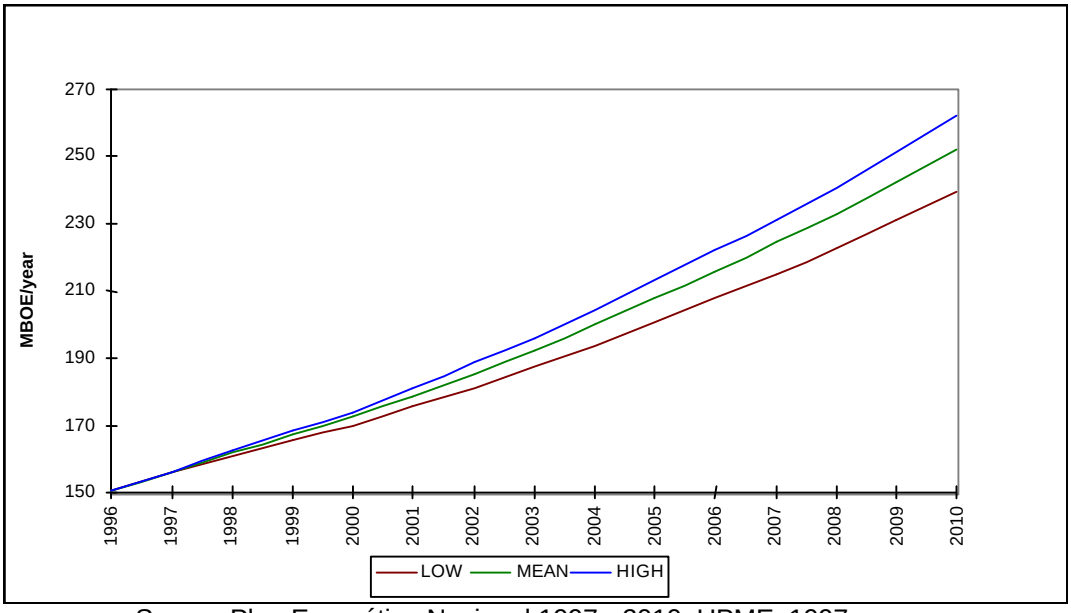
Source: Plan Energético Nacional 1997 - 2010, UPME, 1997

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.

Figure 2. Projected range of final energy demand



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

The short term is the period 1996-2000. For this period UPME included only already defined electricity generation and transmission projects. At the time of publication of the Electric Expansion Plan several of those projects were in the design stage and some others even under construction, which is why the short term is the same for all four strategies

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.

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 [10]. 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 [11], 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

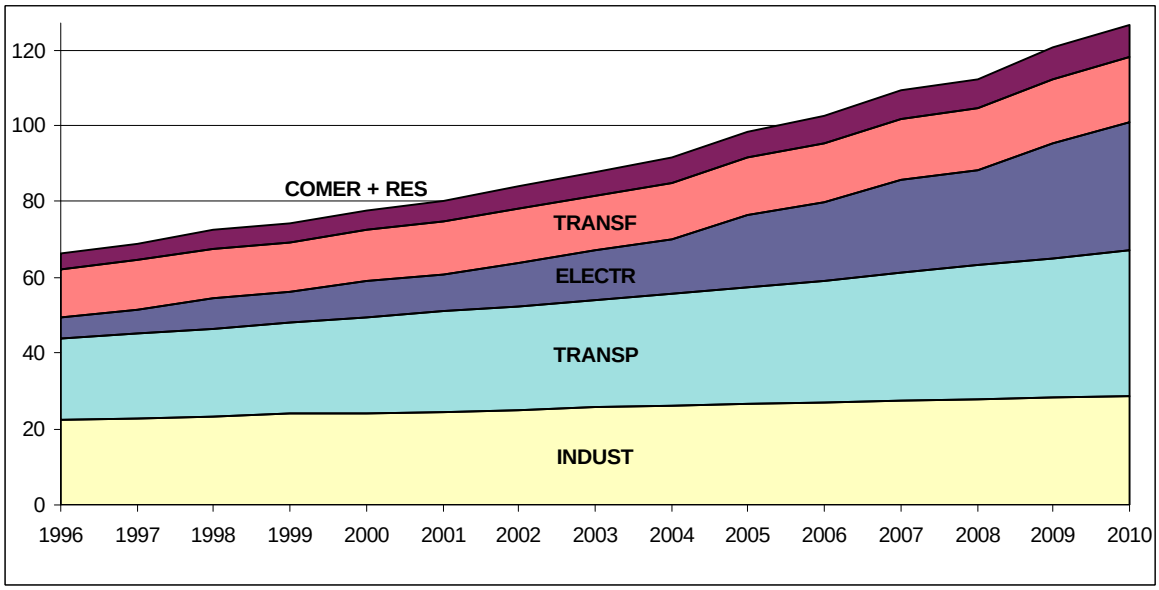
In estimating emissions for the base case, the energy sector and the non-energy sector were considered separately.

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[12] and from the AP-42 standards[13]. 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 Mtonnes in 1996. They show a tendency to grow and are expected to rise to more than 120 Mtonnes 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 (Mton/year)

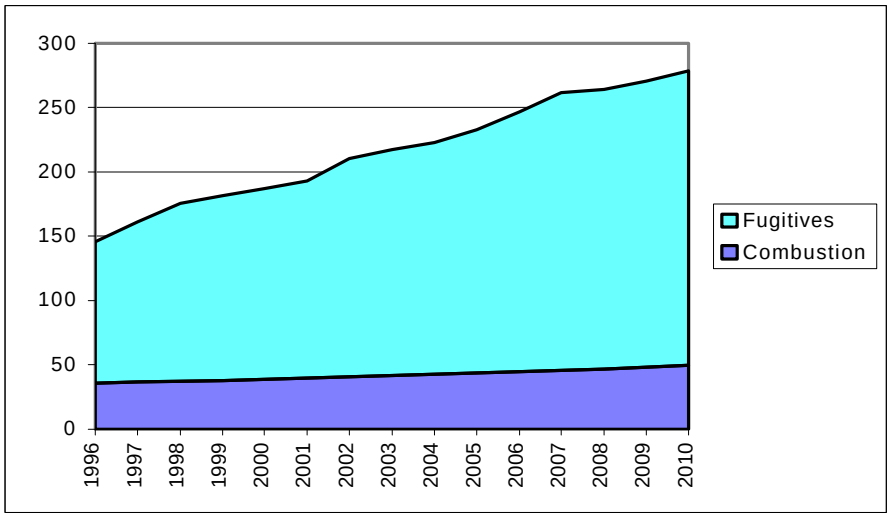


The largest increase in emissions is expected to come from the electric sector. In 1996 the electric sector was responsible for 8% of total CO_2 emissions, but by 2002 this share will be up to 14% and by 2008 as high as 22%.

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'). Figure 4 shows the expected base-case evolution of methane emissions in the energy sector.

Figure 4. Methane emissions in the energy sector (kton/year)



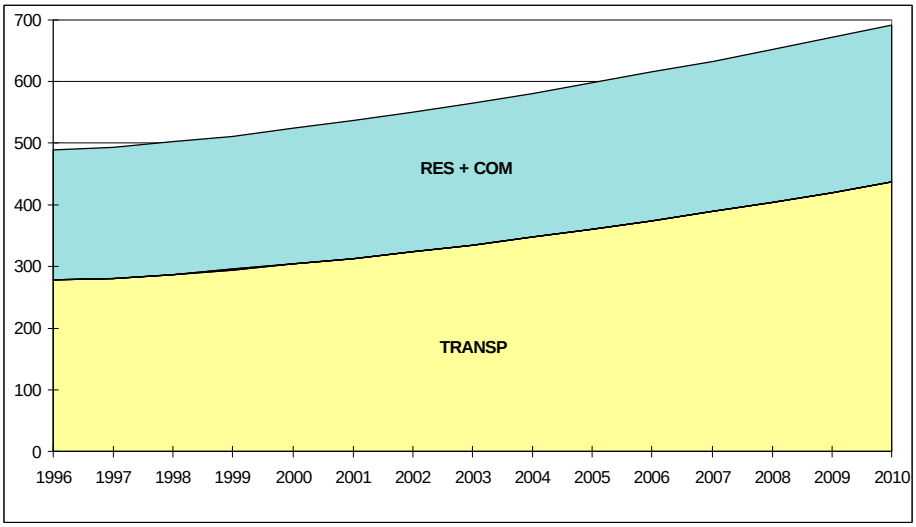
As can be seen from Figure 4, out of total methane emissions in 1996, 146,000 tonnes, 75% consisted of fugitive emissions, while in 2010 their share will rise to 82% because of expansion in coal mining and oil exploitation.

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.

Non-methane volatile organic compounds: NMVOC emissions in the commercial, industrial and electric sectors are negligible compared with emissions in the residential and transport sectors, as can be appreciated from Figure 5. As in

the previous cases a steady increase is registered in emissions from these two sectors. But the residential/commercial sector's share of total emissions falls from 43% in 1996 to 38% in 2008, while the transport sector's rises from 57% in 1996 to 62% in 2008.

Figure 5 NMVOC emissions by economic sector (kton/year)

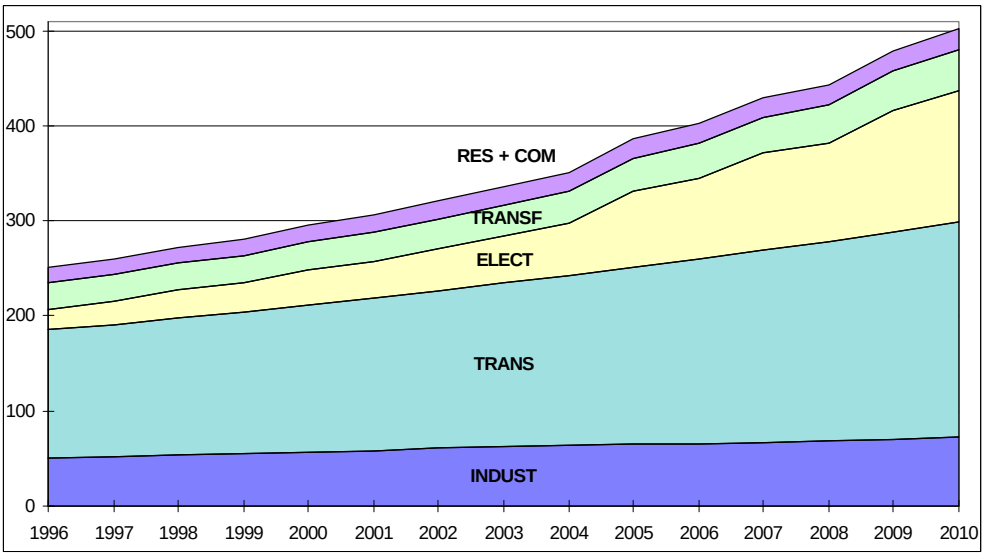


Nitrogen oxides: In Colombia nitrogen oxides (NOx) are mainly discharged by the transport sector (136,443 tonnes in 1996), the industrial sector (48,849 tonnes), and the electric sector (20,738 tonnes). The greatest increase will again be in the electric sector, with projected emissions rising to 138,515 tonnes by the end of the next decade, almost seven times the 1996 level. Compared with the other sectors, the urban and commercial sectors produce negligible quantities of nitrogen oxides.

In 1996 some 250,000 tonnes of NOx were emitted by the seven sectors. Emissions are expected to rise to about 500,000 tonnes by 2010.

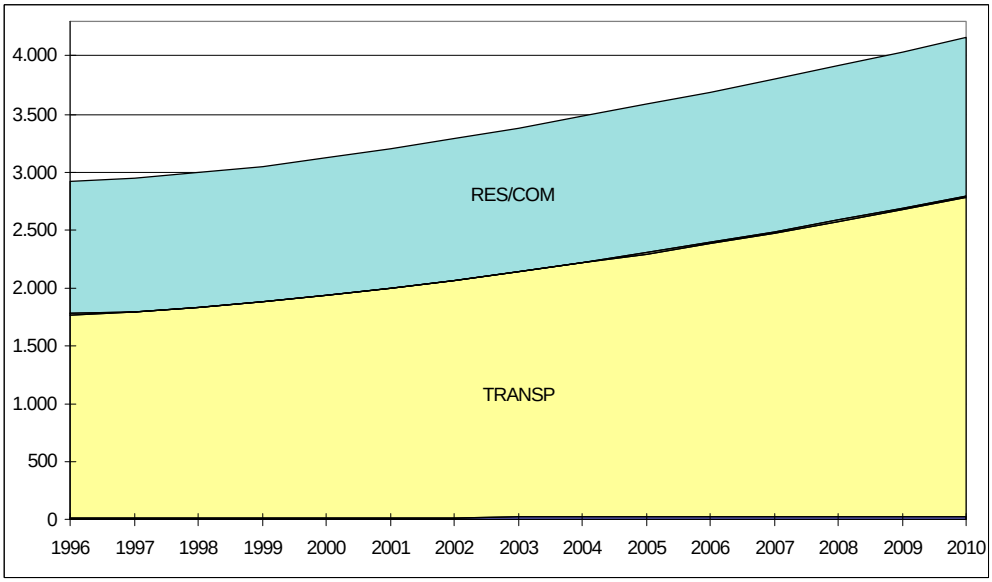
Carbon monoxide: The transport and rural sectors are the chief sources of carbon monoxide emission, discharge from other sectors being fairly low amounts in comparison. A little over 2.9 Mtonnes of carbon monoxide were released into the air in 1996 (Figure 7), and the total is expected to climb to almost 4 Mtonnes by 2010. The main emitters will again be the transport and rural-residential sectors. Over the period 1996-2010 transport emissions rise from 1.8 to 2.8 Mtonnes, while rural emissions increase from 1.1 to 1.4 Mtonnes.

Figure 6 NOx Emissions by Economic Sector (kton/year)



In 1996 the rural sector accounted for 39% of total carbon-monoxide emissions and the transport sector for 59%. The rural share decreases to 34% by 2008, whereas the transport share increases to 64%. The industrial and transformation sectors barely contribute 2% of annual carbon-monoxide emissions over the whole period.

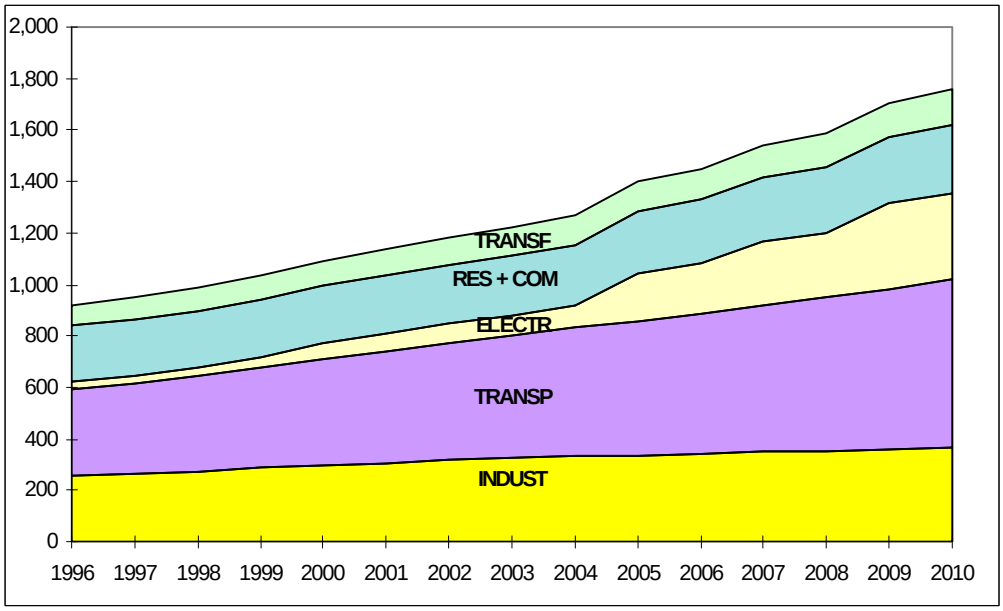
Figure 7. CO Emissions by Economic Sector (kton/year)



Nitrous oxide: The major sources of nitrous oxide (N_2O) emission are the commercial, industrial and transport sectors. In all, some 920 tonnes of nitrous

oxide were emitted in 1996. The total is expected to double by the end of the next decade to about 1,800 tonnes.

Figure 8. N_2O Emissons by economic sector (ton/year)



The electric sector's share of total nitrous-oxide emissions is expected to increase from 3% in 1996 to 16% in 2010. The transport share remains constant over the whole period under study. Other sectors' contributions to the total decrease: the residential/commercial sector's from 23% in 1996 to 17% in 2008, and the industrial sector's from 28% to 22% by the end of the period under study.

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 9 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 9. CO_2 Emissions in Forestry Sector – Base case (Mton/year)

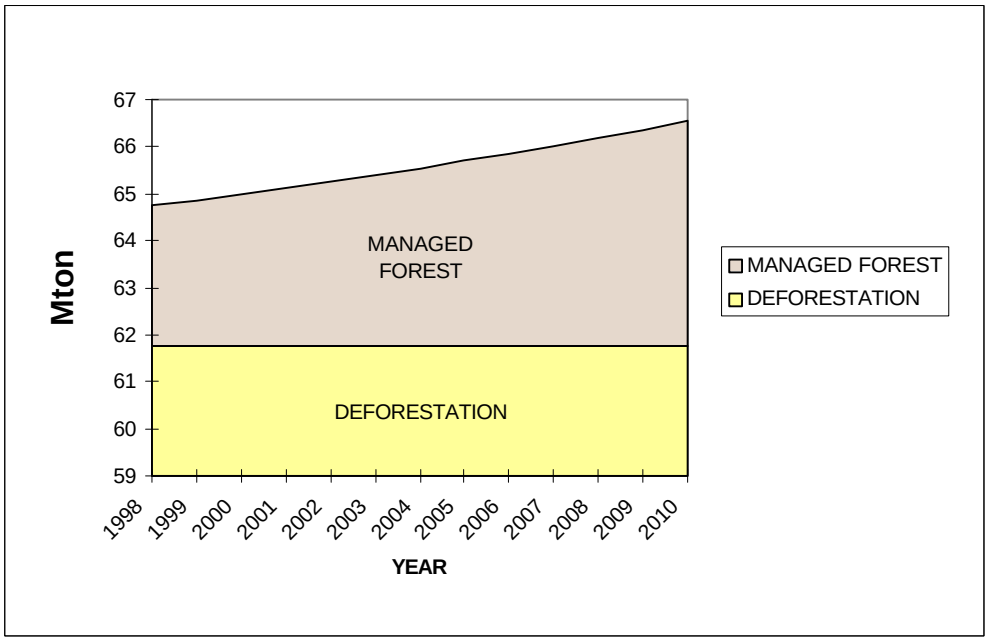
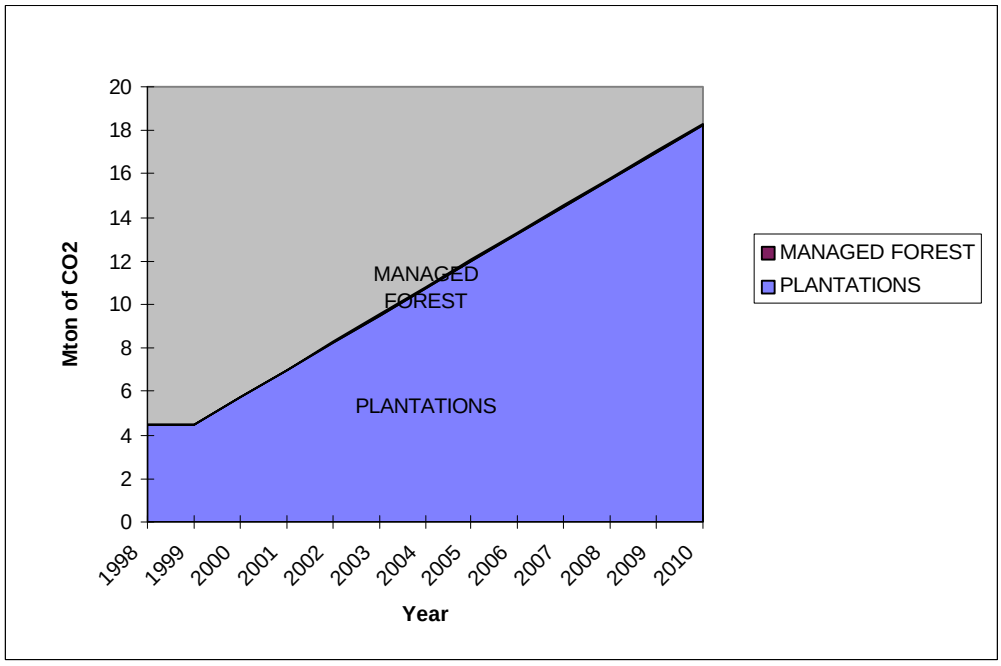
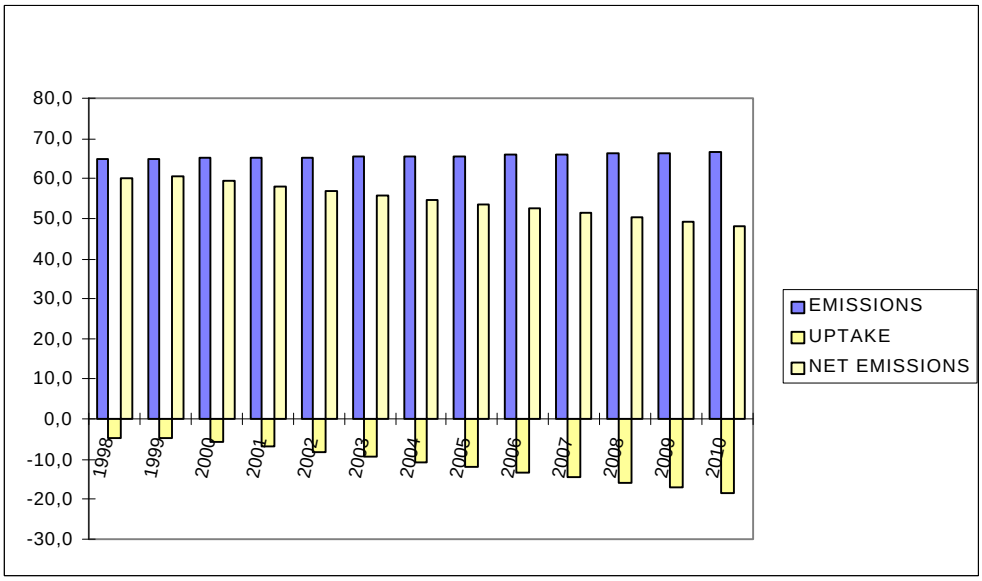


Figure 10. CO_2 Uptake by Forest and Plantations – Case Base (Mton / year)



Carbon-dioxide uptake reduces the subsector's net CO_2 emissions from 60.2 Mtonnes to 48.2 Mtonnes by the year 2010 (Figure 11).

Figure 11. Evolution of $C0_2$ Net Emissions (Emissions and uptake) (Mton / 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.

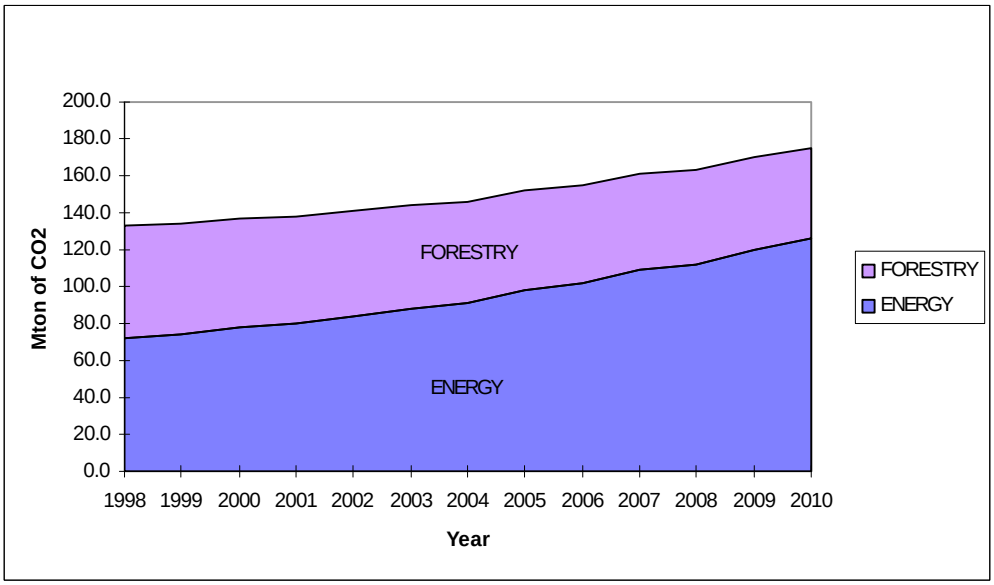
Methane emissions from farming are estimated, under base-case assumptions, at 1.6 Mtonnes in 1996, 1.8 Mtonnes by 2002, and 2.0 Mtonnes by 2008. Enteric fermentation among dairy and meat cattle is the chief source of methane emission, representing 84.5% of the total in 1996 and 87.6% by 2008.

CONCLUSIONS

Net carbon-dioxide emissions

Figure 12 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 12. Total CO_2 Emissions from Energy and Forestry Sectors Case Base 1998-2010 (Mton/year)

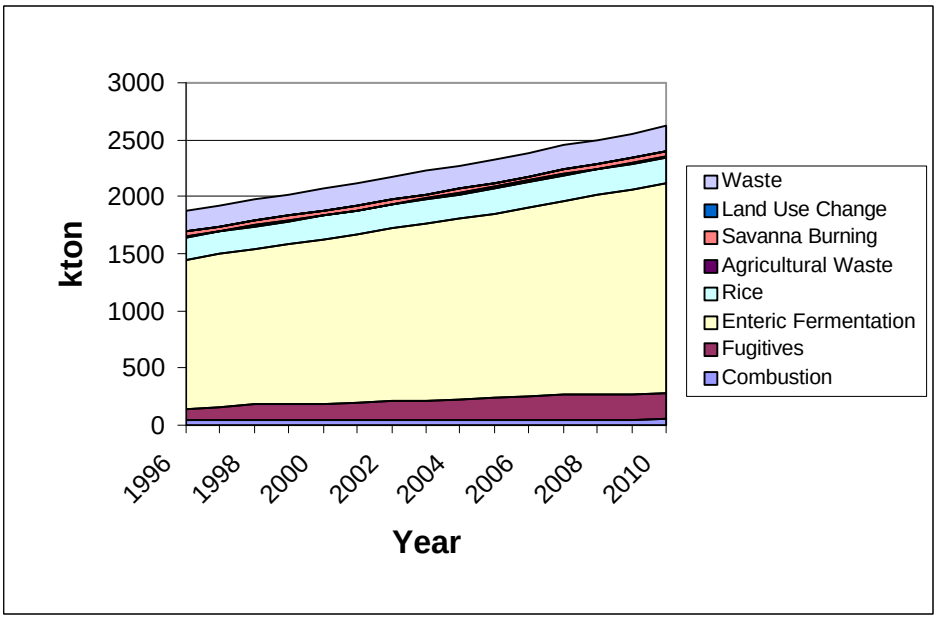


Carbon-dioxide emissions in 1990 stood at 167 Mtonnes, with the energy sector accounting for about 31% (52.3 Mtonnes) of the total and the forestry sector (logging and forest burning) for the rest (111.3 Mtonnes). From 1990 to 1998 the energy sector's expansion also increased its CO_2 emissions from 52 Mtonnes to 72 Mtonnes. In contrast, the forestry sector's CO_2 emissions plunged from 111 Mtonnes in 1990 to 60 Mtonnes 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 Mtonnes by 2010, and to rise in the energy sector up to 126 Mtonnes. Thus total CO_2 emission in 2010 (174 Mtonnes) compared with the 1990 total (167 Mtonnes) shows an increase of barely 8 Mtonnes 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 Mtonnes in 1990 to 126 Mtonnes by 2010, the increase being offset by a reduction in the rate of deforestation over the same period.

Total methane emissions

Figure 13 shows the evolution of total methane emission in Colombia from each type of source over the period 1996-2010.

Figure 13. Total CH_4 Emissions by Source Base Case 1996 – 2010 (kton/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%.

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