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PROYECTO DE ESTUDIO SOBRE EL CAMBIO CLIMATICO EN ARGENTINA

PROYECTO ARG/95/G/31-PNUD-SECYT

INFORME FINAL DEL SUB-PROYECTO ESTUDIO DE MITIGACION DE GASES DE EFECTO INVERNADERO

Buenos Aires, diciembre 1997

EXECUTIVE SUMMARY

1. The problems of climate change in developing countries

Although in the near future developing countries (PVD) are not required to undertake actions to mitigate greenhouse gases (GHG) emission according to commitments contained in Agenda 21, the increase in GHG concentration in the atmosphere and its potential consequences on the climate should be considered by all countries in the planet.

The uncertainty margin is significant, in spite of which consensus exists in the scientific field regarding the fact that the characteristics of global warming are of an anthropogenic origin.

Amidst this context of uncertainty the implementation –or non implementation– of actions to mitigate climate changes' eventual effects should be decided. Bearing in mind that such effects can be significant in socio-economic terms, the principle of caution should be employed when applying policies: whenever the future effect of a present cause is uncertain but can be very damaging or irreversible, it is prudent to act immediately and eliminate the causes that are best known among those on which action can be taken.

Such aspect is especially critical in the PVDs considering that the degree of vulnerability to possible phenomena strategically relates with social groups' capacity to absorb, dampen or mitigate the effects of such changes, which depend on the possibility to have technology, infrastructure and adequate means available.

In general, when discussing the impacts of climate change mitigation actions on the PVDs, the consequences that a mitigation policy implemented in a PVD would have on its own economic and social development are considered. However, the importance of analyzing the impact caused on PVDs' economic development possibilities by a growingly restrictive international context regarding GHG emission should be mentioned here.

In such sense, it should be borne in mind that most of the fossil energy traded in the international market originates in developing countries and passes to industrialized countries. A similar situation could appear in the market of other energy-intensive products, especially basic goods such as steel and other metals. On the other hand, since globalization started to evidence the need for economic adjustments in industrialized countries, the idea that international trade should be somehow regulated to prevent disloyal competition in the markets started to take root. Some voices started to demand that social and environmental aspects be considered in such regulations. The arguments presented in COP3 to delay the fulfillment of commitments by industrialized countries directly relate to such aspect.

Such considerations about impacts on development are not aimed at debating the inconvenience of climate change mitigation, which according to all analyses should be implemented in the short term. It seems important, however, to bear such aspects in mind at the time of agreeing on actions to be implemented and cost allocation.

The present degree of concentration is the result of a historic process during which one part of the planet used a Natural Capital, a commonly owned resource, applying, in the absence of control and regulation the "Law of Capture" overexploiting said resource and turning it from a "pure" into an

"impure" good, bringing about consequences for its own population and the rest of the planet. The short and long-term consequences are the additional costs to be paid by not having "free access" to such resource.

Such differential responsibility and the incorporation of equity-related considerations to climate change mitigation would force to alter the whole methodological approach to debating this issue, which can therefore not be omitted from a report on Greenhouse Gases mitigation actions.

2. Diagnosis of the Argentine situation

The socio-economic context

The Argentine economy has gone through successive development stages. The present one, dating back to the late '80s involves many causes and conditioning factors and exhibits two major features: greater internationalization of the economy and the State's withdrawal from goods and services' production.

The present economic program comprises three lines: prices stabilization on the basis of a convertibility plan, deregulation of the domestic market and State reform.

As a result of such reforms and a certain favorable international situation, growth started to expand. According to official estimates, the rise in GDP as of 1991 was significant, encouraging however a structural trend that evidences a relative lower participation by the primary and secondary sectors.

The economic reactivation that started in the second half of 1996 apparently resulted from both improvements in foreign funding conditions and growth in certain industrial areas within the MERCOSUR.

The energy context

The Argentine energy system evidences the major role played by Oil (50%) and Natural Gas (36%) in primary energy production, versus the low relevance of fuels of vegetable origin and coal, although such percentages may be overestimated because of deficiencies in the Energy Secretariat's statistics system to grasp the production and use of fuels of vegetable origin (wood, agroindustrial waste and charcoal).

Imports of primary energy sources are scarcely relevant at present, accounting for less than 4% of the country's domestic gross supply. On the other hand, the net balance of the foreign trade of crude reached about 37% of the domestic production in 1995, tripling the sale of petroleum products abroad. To that date exports had not enhanced Natural Gas production, a situation that changed in 1997 when two gas pipeline to Chile became operational and could increase even more when other export projects materialize.

Electric power plants act as a crossroad between various energy chains, as all the products represented are their input and they constitute the major intermediate use of energy offered. Petroleum products used in electric power plants are presently quite low (7% of total inputs) versus natural gas (42%) and hydraulic energy (39%). Gas' low relative price when compared to petroleum products is restraining the use of the latter solely to cases of gas supply shortages, either seasonal or permanent.

A totally different situation is that of end-use energy consumption, in line with energy for the different socio-economic sectors. In this case, petroleum products supply 50% of the demand and

natural gas one third. Petroleum products are mainly used for transport and agricultural machinery, while industries, trade and families have substituted petroleum products almost totally for natural gas in thermal uses. Consequently, and unless the natural gas substitution process evidenced in the past in such sectors reverses in future, the petroleum products' domestic market shall be essentially defined by the evolution of the transport sector and to a lesser extent by the mechanization of agriculture.

The State reform, launched in 1980, resulted in a substantial change in the institutional structure and the regulation of all energy-related activities, which evidenced different features depending on the energy chain. In general same were characterized by a transfer of the ownership right (privatization), establishing new regulatory frameworks and deregulation of one or more segments of the various production chains.

The supervision and general regulation of the electricity and gas industries is the responsibility of Federal Regulatory Agencies, established by law in the scope of the SE as autonomous bodies.

The crude production increase geared a 33% natural gas production growth between 1990 and 1995, slightly higher than the gas' domestic demand rise (30%) which was offset by means of a reduction of imports from Bolivia.

Oil companies' interest in expanding their activities in the country is clearly evidenced by an ongoing search for new markets to sell their production.

Generation in the electricity industry has also been very active since 1992. After the reform about 3400 effective MW were installed in 3 years -1/3 of the maximum load recorded in 1995- increasing reserves to 57% of the maximum capacity demand. However, 61% of the capacity added was from hydroelectric plants already under construction with public funds before the reform. However, the investments made by private players focussed totally on natural gas-based thermal generation. Such process is leading the electricity industry to a growing natural gas dependence, regarding both availability and price.

The government has driven increases in hydrocarbons' production, especially oil, without substantial restrictions on domestic oil uses. Should the country's low reserve horizon persist it could result in reviewing such policy, particularly affecting exports.

The environmental context

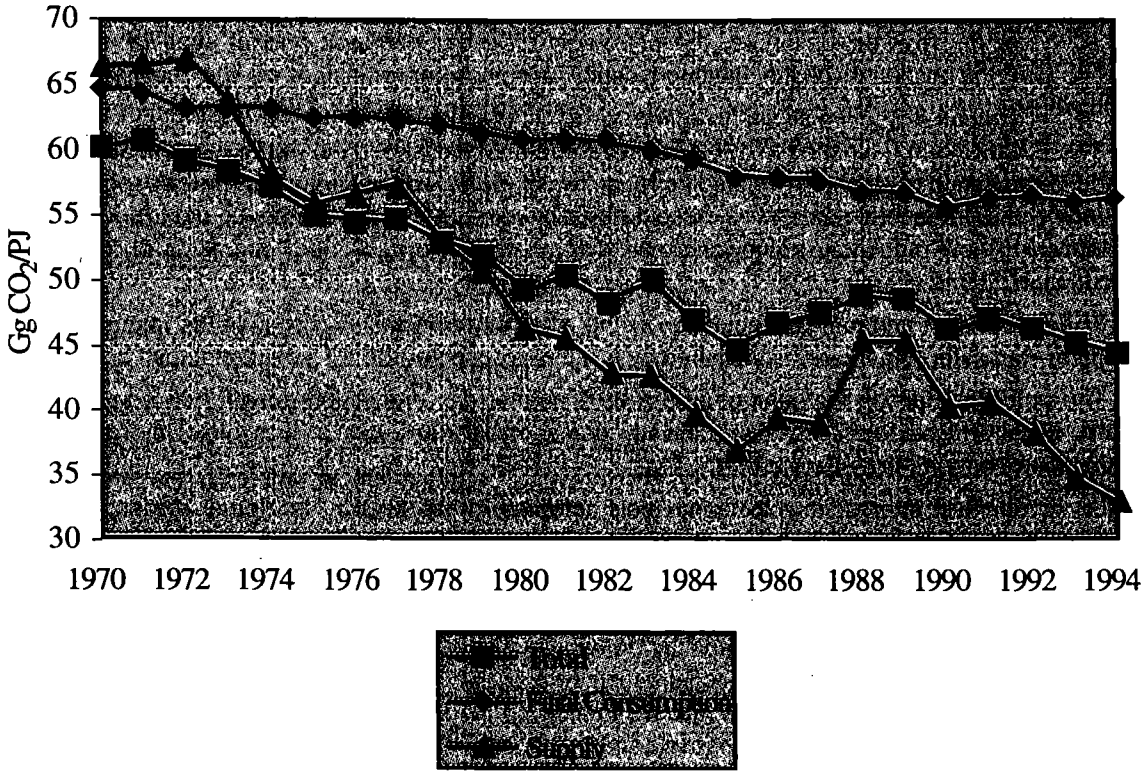
The Argentine public perception relative to environmental problems is changing fast. Toxic waste management, soil degradation and streams' pollution are more often an issue of public concern. On the contrary, air quality does not seem to rouse general concern, except for toxic compounds concentration in downtown Buenos Aires. The public opinion seems to be less concerned by GHG emission, although a growing interest can be noted regarding climate change potential effects.

As expected, the Inventory shows CO_2 emission's clear preeminence over the remaining GHG from energy production and consumption. Although the energy system's CO_2 emissions evidence an upward trend values are still very low when compared to industrialized countries' indicators.

Presently, 70% of CO_2 emission come from final energy consumption whereas the remaining 30% is accounted for by energy supply-related activities. The Transport sector is not only responsible for 32% of total emission, but its consumption pattern largely contributes to total emission evolution. The industry and buildings' energy consumption, despite an almost 16% contribution to total emission each, have a moderate impact due to the high natural gas share in their energy consumption.

As for the environmental efficiency of the Argentine energy system, the following graph illustrates CO_2 evolution per energy unit supplied.

Evolution of CO_2 specific emission



As seen, the amount of CO_2 emitted from each PentaJoule supplied shows a very clear trend. Total specific emission decreased persistently throughout the whole period being today 25% lower than in 1970.

It can be stated that the Argentine energy system has reached a degree of development such that in future an important effort shall be required to dampen the effects of economic growth on CO_2 total emission.

3. Methodological aspects

Following the guidelines set forth by the World Environment Fund (Fondo Mundial para el Medio Ambiente) (FMAM) for climate change mitigation studies, two future scenarios of the system under analysis are developed. One of them *(Base Scenario)* refers to the evolution expected given the system's present dynamics, without resorting to actions or explicit policies to abate greenhouse gases' (GHG) emission or to increase greenhouse gases (GHG) absorption capacity. The second (*Mitigation Scenario)* on the other hand, involves selecting a set of climate change mitigation options, to evaluate the benefits derived from its implementation.

The formulation of scenarios is based on a *Diagnosis* allowing to understand the relations between economy-energy and energy-environment, as well as the economic performance and the energy system's behavior, analyzed in the present study. The impact on atmospheric GHG accumulation is also studied. After the *Diagnostic* stage and prior to formulating the *Mitigation Scenario*, mitigation options available in the sectors under analysis are identified and characterized.

In the case of the Base Scenario, efforts were made to reproduce business strategies as closely as possible in the context of the development expected in the Argentine socio-economic system, resorting to the experience acquired since energy deregulation. To formulate the Mitigation Scenario the options available in the industry, transport and energy industries themselves were analyzed, selecting first those considered easier to implement although the objective was to include enough industries so that the country's mitigation potential could be assessed.

Based on these hypotheses, the energy system's detailed operation is analyzed in both Scenarios controlling energy flows' consistency, from reserves to consumption, using the LEAP model (Long-range Energy Alternatives Planning System) developed by the Stockholm Environment Institute - Boston Center at the Tellus Institute.

LEAP is a simulation model that contains 6 modules and an environmental data base used to calculate environmental impacts associated to the energy system's expected evolution. The purpose of the 6 modules is to analyze: Demand, Biomass, Environment, Scenario Assessment, Results' Aggregation.

On the basis of a data base generated specifically on the basis of emission coefficients adopted in the Report on GHG Emission Inventory in Argentina, the LEAP supplied the GHG emissions compatible with those calculated in the Inventory Study for 1990 and 1994.

4. Developing scenarios

The International Context

In the face of a growing globalization process, the Argentine situation evolution will largely depend on the international context. Such dependence becomes evident at different levels, of which the economic, technologic and energy-environmental are the ones relevant to this study.

Economic aspect

The globalization process shall require central economies to further adjust, especially in Europe. However, after the adjustments made since the beginning of the eighties, global growth is expected to be slow albeit steady in the long term, although more moderate consumption patterns shall be adopted.

The geographic displacement of production towards less developed countries, geared by globalization, will not necessarily cause recession in the central economies due to the development of other activities in the service area, the existence of positive financial flows and the control of technology resulting from the corporate ownership structure at international level. However, unemployment may generate substantial changes in consumption and labour patterns that could impact other regions as well.

Industrialized countries shall gradually eliminate subsidies and tariff barriers imposed on certain raw materials originating in developing countries, especially Latin America. However, the greater potential for trading agricultural products shall derive from global economic growth.

It is assumed that the international financial market shall be more stable, leading to more advantageous funding rates and terms. Conditions for foreign debt repayment shall also improve.

The following are the long-term economic growth hypotheses:

Region	Rate Period 1995/2030		
	1995/2015	2015/2030	1995/2030
Africa	3.0%	2.2%	2.4%
Asia (PVD)	6.5%	5.6%	5.9%
E. Europe	4.3%	3.7%	3.9%
M. East	2.5%	3.2%	3.0%
L.America	3.8%	3.9%	3.9%
Japan	2.5%	1.9%	2.1%
Europe	2.5%	2.0%	2.1%
USA+Canada	2,5%	2.2%	2.3%
TOTAL	3.0%	2.8%	2.8%

Technological aspect

Future technological development is part of the international context in which developing countries (PVD) act as "technology takers". The PVD will only differ on the basis of the advantages and obstacles posed to the penetration of new energy technologies and to the production of goods and services, as a function of their strategies to join international markets.

Based on the Workshop "Technological Innovation in the use of energy", attempts were made at establishing a clearer framework on future technological expectations. The results were extremely useful to elucidate international efforts in the development and introduction of new technologies. The conclusion drawn was that the international research dynamics and the introduction of new technologies evidence a fast development and are fuelled by economic factors and environmental concerns.

It has been assumed that the technologies available in the international field in the next 30 years shall not be notoriously affected by the position of industrialized countries' governments with respect to climate change.

Energy-environmental aspects

International energy markets perspectives shall strongly depend on the international attitude vis-a-vis environmental concerns.

Although the international community is rapidly becoming aware of the fragility of the environment and the dangers of its ongoing degradation, effective environmental protection involves very deep changes in consumption patterns and in present economic organization standards, difficult to implement in the current political and economic context. A proof of this is the obvious difficulty to reach an agreement on governments commitments to abate GHG emissions.

In spite of the uncertainty on GHG reduction margins and the terms that will finally be agreed to attain such levels, the PVD will be strongly affected by such process. Regardless of the commitments industrialized countries may locally undertake, pressure shall be exerted on the PVD for them to contribute to climate change mitigation. In such sense restrictions shall be imposed on their products in both industrialized countries' and financial markets, based on environmental considerations.

As regards the evolution of energy products' international markets and in spite of the fact that oil's share in primary energy supply has decreased, its price still is a benchmark for energy, given its relative importance compared to primary energy sources, the fact that it is a tradable good and also a fuel substituting for other sources.

In the context of OPEC's loss of power, the European Union's steady import percentages and increased levels by the U.S. and China, Russia's production upkeep and increases in Great Britain's and Norway's supply, a certain stability is forecast for the price of crude oil with a slightly upward trend, especially after 2010. Crude oil international prices act as benchmark to define the evolution of petroleum products and gas' domestic prices.

Domestic socio-economic context

The socio-economic scenario assumes as a starting point that the growth of regional blocks shall basically depend on a greater opening of Northern developed countries' markets to PVD products.

At a regional level, the agreements signed within the MERCOSUR shall help stabilize national economies and lead to a search for more coordinated solutions among countries. In turn, countries' stability shall become a key issue for the success of MERCOSUR. The integration process will not only increase exchange but also result in greater sectoral complementation and increased competitiveness.

Argentina will mostly be geared to agroindustries and mining, which involve activities that rely on and impact different chains. Significant impact will result from investments in the Agro-industries, Mining and complementary investments in these sectors, many of which have a strong environmental impact.

Growing specialization is seen in sectors devoted to the processing of natural resources, be they traditional or industrial commodities (non-mineral oils, iron and steel industry, petrochemicals, natural gas, aluminum, fish flour, etc) whose plants have undergone strong restructuring to approach international efficiency levels, although in some cases, with noticeably lower production scales.

As for the exporting profile, all indicators seem to prove that major items will closely relate to the production of gas, minerals, fuels and commodities in general, with a low added value.

Long–term growth of the GDP

Interannual growth rates and GDP values by sector in 10^6 U$S of 1994

	GDP 1995	a. rate 1995-05	GDP 2005	a. rate 2005-10	GDP 2010	a. rate 2010-20	GDP 2020	a. rate 2020-30	GDP 2030
Agro-industries	21975	4.4%	33729	7.5%	48410	5.5%	82713	5.5%	141288
Mining	6953	3.1%	9434	8.0%	13863	7.0%	27261	6.0%	48831
Industry	71874	3.8%	104597	5.0%	133493	5.2%	221609	4.5%	344162
EE, GD & Water	5705	3.8%	8261	4.8%	10453	4.0%	15458	4.0%	22876
Construction	15155	4.1%	22722	4.5%	28324	3.8%	41124	4.5%	63845
Commerce	46535	5.2%	77158	4.8%	97528	3.8%	141620	4.2%	213703
Trans. y Comm.	13907	5.1%	22921	5.4%	29808	4.5%	46306	5.0%	75427
Finances	41877	4.1%	62386	4.2%	76623	4.0%	113429	3.8%	164718
Services	45108	2.9%	59773	4.0%	72726	3.2%	99654	3.5%	140557
TOTAL	**269089**	**4.1%**	**400981**	**5.0%**	**511228**	**4.4%**	**789174**	**4.4%**	**1215407**

As a result of the assumptions relating to the long term growth path, the production structure would tend to concentrate in goods producing sectors, while service sectors would decrease in relative terms.

From the production standpoint the most salient feature shall be a relative reprimarization of the economy. However, such trend would be offset by the industry's relative consolidation. Argentina would thus grow above the region's average, at rates however close to those forecast for the region.

On the other hand, trade would benefit in the long term from a favorable ratio in the prices of primary export products and the high added value of agroindustrial exports.

5. Results expected in the Base Scenario

The evolution of energy consumption

This scenario assumes that government intervention in future energy markets shall not place barriers to private businesses, devoting only to the implementation of policies aimed at: controlling competition levels in domestic energy markets, promoting the creation of regional energy markets on competitive bases, guarantying future energy supply, enhancing energy efficiency.

It is assumed that energy supply follows the trend in which energy efficiency exhibits a dynamic behavior, where improvements occur "naturally" without specific intervention.

Total final energy consumption

SOURCES	1995 10^6 Gj	1995 %	2005 10^6 Gj	2005 %	2010 10^6 Gj	2010 %	2020 10^6 Gj	2020 %
Hydrogen							16.59	0.4
Biomass & O. Prim.	94.05	5.2	129.93	5.4	162.03	5.3	250.11	5.4
Coals	3.58	0.2	4.80	0.2	5.88	0.2	9.09	0.2
Petroleum Products	700.90	38.9	805.14	33.4	978.11	32.2	1475.11	31.9
Electricity	200.92	11.1	324.03	13.4	416.40	13.7	634.25	13.7
Distributed Gas	660.75	36.7	956.21	39.7	1246.10	41.1	1924.19	41.6
GLP	59.24	3.3	69.18	2.9	75.86	2.5	91.84	2.0
Other Gases	26.77	1.5	41.67	1.7	50.63	1.7	69.46	1.5
Non–Energy	56.52	3.1	78.53	3.3	100.16	3.3	158.85	3.4
TOTAL	**1802.73**	**100.0**	**2409.49**	**100.0**	**3035.17**	**100.0**	**4629.49**	**100.0**

The annual cumulative growth rate between end years (1995/2020) reaches 3.8%.

Energy productivity evolves, measured on final consumption (GDP/Final Consumption), increasing by 14% for 2020 compared to 1995 values.

Total final consumption increases by the following percentages compared to base year figures:

1995	2005	2010	2020
Base	+34%	+68%	+157%

There is a penetration of distributed gas which becomes the most important source, while Petroleum Products, PLG and Other Gases lose ground and Electricity grows.

As for the share of various sectors, it should be pointed out that:

The most dynamic sector is Agriculture, Silviculture and Fishing, whose share increases 1.63 points (27%) in 2020 with respect to the base year.

The industrial sector's relative importance increases 1.16 points (4.5%) in 2020.

The Residential, Commercial and Institutional and Own Consumption sectors' share drops.

The Transport sector's share slightly decreases, with a percentage above 28% it still remains a higher final consumption sector.

Including supply-related data, considering that trends will remain stable in the electricity, gas and oil industries, the following should be pointed out:

The major role of electricity generation, based on combined cycle thermal power plants (90% of thermal generation).

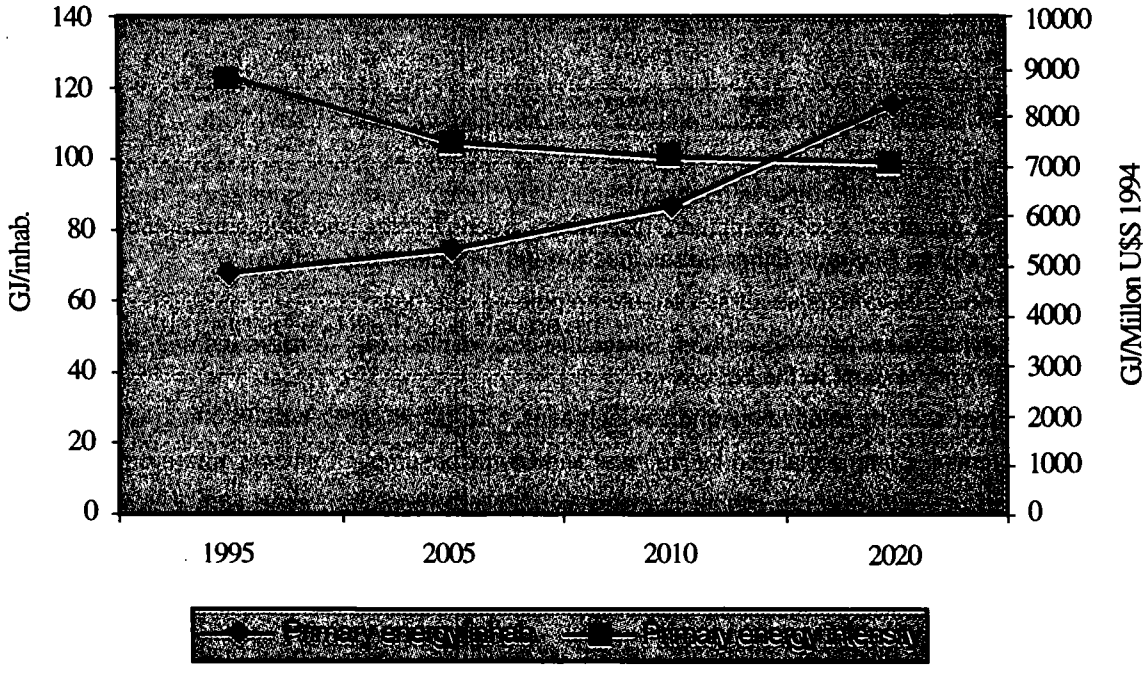
The need to undertake very significant exploration efforts to meet the scenario's natural gas requirements. Discoveries shall be kept at a pace implying the addition of 70000 million cubic meter of gas a year to keep an adequate reserve horizon (8/9 years).

Crude oil's domestic production is assumed to plateau in 52 million cubic meter a year by the year 2002, a level that could be maintained until 2005. From such date, production would decline to reach 35 million cubic meter in the year 2020. Such crude oil production would be insufficient to meet the needs of refineries which would then have to import one third of their requirements.

Primary energy consumption evolution implies an increase in natural gas' share, a drop in coal and nuclear and a substantial loss in oil and petroleum products.

An increase in energy efficiency is also expected as a result of technological progress and the growing need to sustain market competitiveness.

Energy intensity and per capita consumption



GHG Emissions

According to the GHG Emissions Inventory results, nitrous oxide (N_2O) emissions from the Argentine energy system are clearly negligible, 0.2% of CO_2 emission, even considering that their warming potential is equivalent to 320 fold that of CO_2. (1) Given that such ranges fall within assessment errors, it has been decided not to measure future N_2O emission and restrict the analysis to CO_2, CH_4, NO_x and CO emissions for both scenarios.

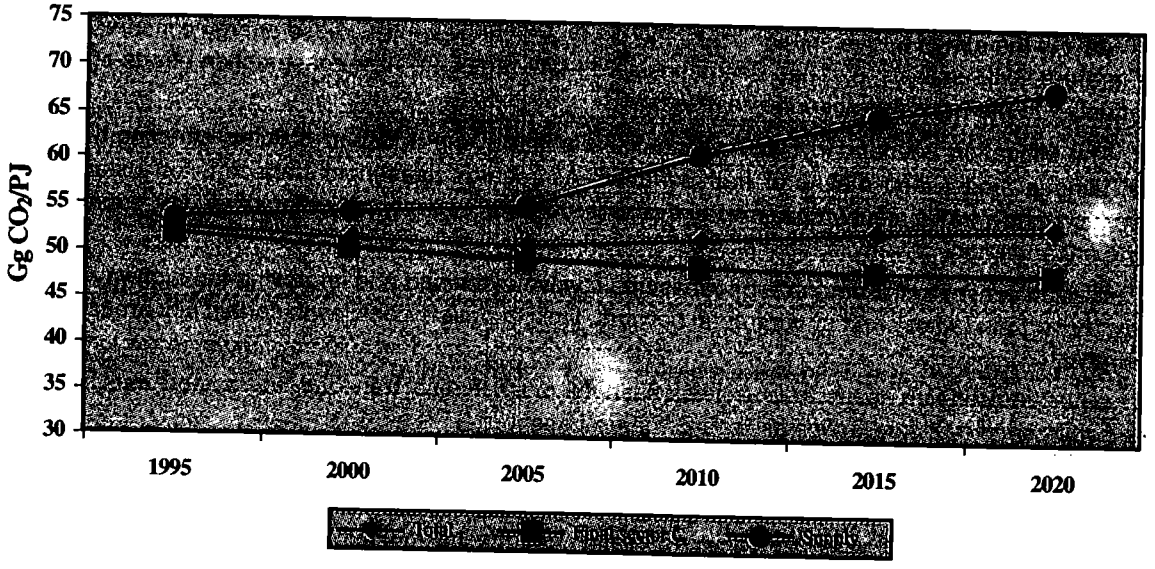
Gas Type	Unit	Inventory		Mitigation study			
		1990	1994	1995	2005	2010	2020
CO_2	Gg	97402	109001	118190	143900	182620	281660
CH_4	Gg	371.8	474.9	35.0	61.1	108.4	203.1
NO_x	Gg	535.9	619.2	684.1	839.3	1083.8	1731.5
CO	Gg	1510.7	1735.7	1752.9	1624.5	1813.1	2052.0
CO_2 Equiv.		132479	150611	151671	183842	234067	362052

(1) In order to compare various GHG volumes the following factors were adopted for heating potential
CH_4: 24.5 (Source UNEP-RISO)
N_2O: 320 (Source: UNEP-RISO)
NO_2: 40 (Source: IPCC)
CO: 3 (Source: IPCC)

The most substantial energy system's emissions originate in carbon dioxide, although the growth of methane emission shall be faster in future. In spite of its different growth pace, direct CO_2 emission accounts for 78% of the total throughout the period, whereas methane would barely exceed 1% in the horizon year.

The "environmental efficiency" of energy used by the whole energy system and various consumption sectors and/or energy supply-related activities can be measured by emission's specific coefficient.

CO_2 specific emission



As shown in the graph total specific emission would remain relatively stable throughout the whole period under analysis. Such total specific emission's long term stability implies interrupting the historic trend prevailing in the last 25 years affected by a 25% drop.

As for methane emissions, in spite of the expansive context of gas production and consumption, the gas industry as a whole would increase its total methane emission by 12% throughout the period.

The evolution of NO_x emission will fundamentally rely on three sectors: transport, agriculture and cattle breeding and electricity generation. The increase of conventional thermal generation, even burning natural gas, would increase NO_x emissions from electricity power plants at a pace higher than that of the whole energy system.

As for CO, practically 99% of CO emission originates in final consumption sectors, although the growth in emission from power plants will prompt a rise in energy supply-related activities' share which will anyhow account for under 2% of the total in the horizon year.

6. The Mitigation Scenario

From this study's perspective, the Argentine Mitigation Scenario only differs from the Base Scenario to the extent it implies the implementation of options and actions to abate GHG emissions within its territory. The electricity industries' organization and the operators' interest shall remain unchanged, although development strategies should adapt to the new context outlined by official policies to mitigate climate change.

The mitigation options

As it is the aim of this Scenario to take the best opportunities to decrease energy consumption and therefore GHG emissions, it has been considered that regarding final consumption efforts should be oriented to the transport and industrial sectors.

The Mitigation Scenario involves substantial changes in the transport policies, affecting the share of various modes and means of transportation. As regards passenger transport, for instance, the impact of new traffic measures has been evaluated, as well as the substitution of modes, sources, and the enhancement of vehicle technology.

In such sense, traffic organization measures involve extending and improving the highway system, expanding the railway and underground network, limiting private vehicles in certain city areas, among others.

Mode substitution focuses in the increase of mass public transport to replace cars and the substitution of trucks for trains as regards cargo transport.

Additionally, less emitting sources should also be promoted (CNG) and a decrease in the age of the car fleet as a way to improve its mean specific consumption.

In the case of industry, actions focus on heating and mechanic uses, while the role of cogeneration is also being considered. As for heating and mechanic uses, changes in processes are assumed, as well as the partial replacement of equipment and general preservation measures.

As for supply-related activities special attention was given to electricity generation as it involves the highest fuel consumption within the energy sector. In this case mitigation options cannot be based on improving energy efficiency, considering the high future performance of conventional thermal stations. Therefore the search aims at GHG emission-free technologies.

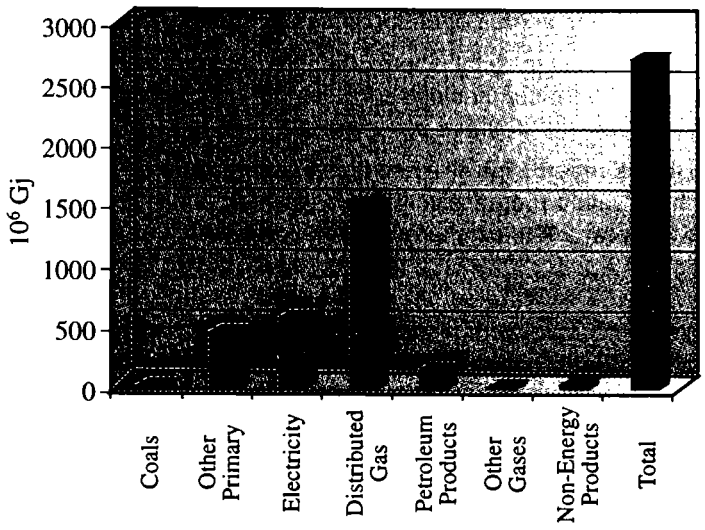
The effects of mitigation measures

The Industrial Sector

The hypotheses assumed on the possibility of undertaking mitigation actions in the industrial sector by improving present equipments' efficiency, sources' substitution, incorporation of more efficient technologies and processes brings about an impact that might be considered spectacular. The difference between both scenarios is 24.7% in 2020. Of such savings, distributed gas accounts for 55% and electricity for 20%. The energy-intensive industry drops its consumption by 21.2% whereas non-energy intensive industry decreases consumption by 29.5%, in both instances compared to base scenario figures.

Effects are illustrated in the following graph, which shows that the responsibility for lower consumptions lies in distributed gas, electricity and other primary sources.

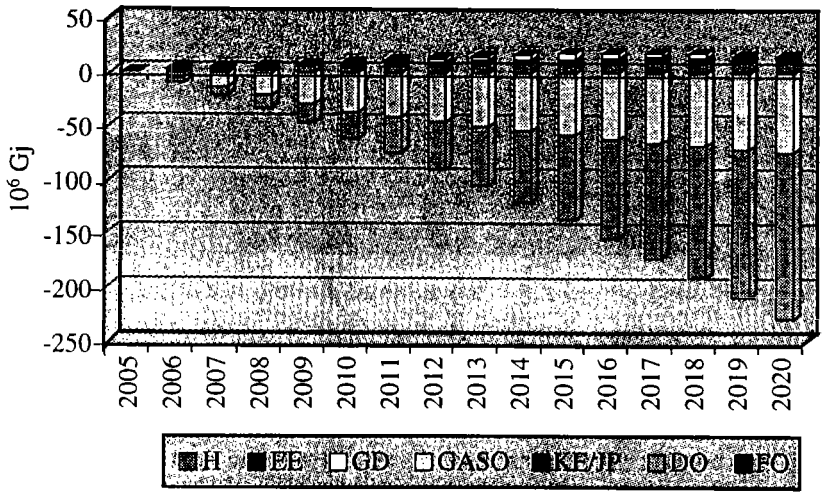
Accumulated Savings by Source



The Transport Sector

"Savings" accumulated as a result of greater efficiency amount to 1476 million Gj, i.e. 1.35 fold the annual consumption projected for 2020, and close to three fold the base year consumption. The lower consumption concentrates in diesel oil and gasolines, and to a lower degree in kerosene/JP.

Annual difference in fuel consumption



Considering highly emitting sources' lower consumption, the penetration of zero emission sources such as electricity and hydrogen is achieved (at least at consumption level). Hydrogen's accrued differential consumption is 113 10^6 Gj and that of electricity 32 10^6 Gj. Distributed gas (CNG) accounts for 42 10^6 Gj additionally accrued and fuel oil 8.61.

The electricity supply sector

In spite of the lower growth rate of electricity requirements in this Scenario compared to the Base Scenario, in coming years the pace of new power plants' incorporation is kept up, considering that the decision to install most of them has already been made and they are already under construction. As for the remaining ones, they represent operators' need to improve their market competitiveness.

In such situation it is possible to install about 5000 MW less than in the Base Scenario. The search of GHG emission-free generation technologies implies not only savings in installed capacity but also a radical change in the structure of added power plants.

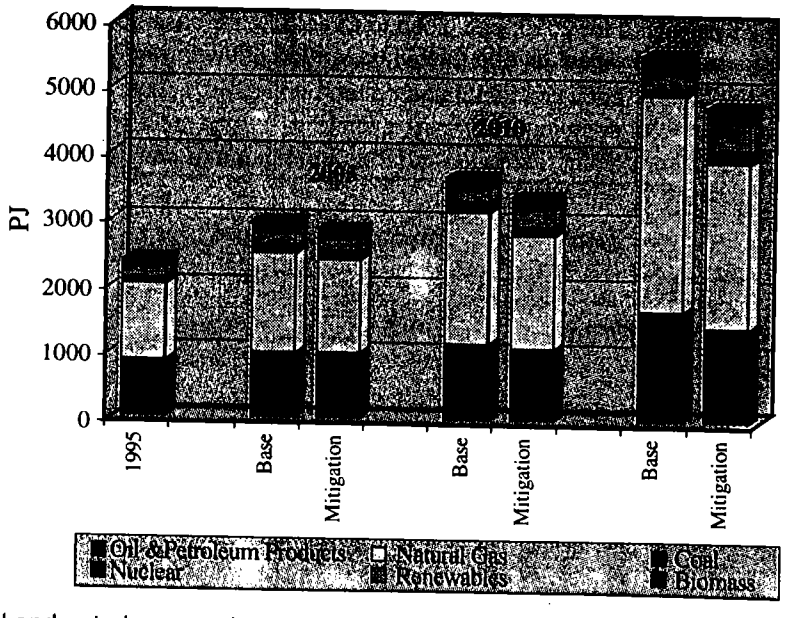
Both Scenarios differ as regards the size and type of energy sources consumed in power plants. As for structure, fossil fuels would progressively decrease their share and reach 54% of power plants' total consumption in the year 2020, compared to 82% forecast in the Base Scenario.

Primary energy consumption

Considering the functioning conditions of the Mitigation Scenario, primary energy consumption growth in the next 25 years would be equal to 2.9% accrued annual rate, becoming faster after the year 2005 (3.5%).

The mitigation actions selected, especially in the electricity sector, imply greater diversification than in the Base Scenario regarding primary sources' consumption.

Primary energy consumption



In this case oil and petroleum products' loss of share (7% in the next 25 years, just like in the Base Scenario) would be captured at the same pace by natural gas and renewable sources (3% each) and to a lesser extent by nuclear fuel (1%). Although renewable sources include both hydro and wind electricity and hydrogen, the strongest impact in terms of primary energy consumption lies in hydroelectric power plants construction. Anyhow, natural gas shall still be the major primary source as regards consumption, with a maximum 52% penetration in the horizon year.

Mitigation actions' impact on the Argentine economy's energy intensity are clearly observed when comparing the growth expected in both Scenarios. Primary energy consumption per GDP unit shall decrease 30% by the end of the period, compared to present figures. This implies a 10 point reduction above Base Scenario's forecasts.

It is interesting to point out that considering equal "energy service" supply in both Scenarios, per capita primary energy consumption after mitigation actions shall be about 14% lower than the Base Scenario forecasts for the year 2020. However, the fast growth rate assumed, together with Argentina's low demographic growth rate would result in a clearly upward trend in the country's per capita primary energy consumption.

GHG emissions

The expected evolution of the four gases under analysis in the Mitigation Scenario appears in the next Chart, where values corresponding to the base year and the horizon year in the Base Scenario were also included to facilitate the comparison between both Scenarios.

GHG Emissions in the Mitigation Scenario

(in Gg)

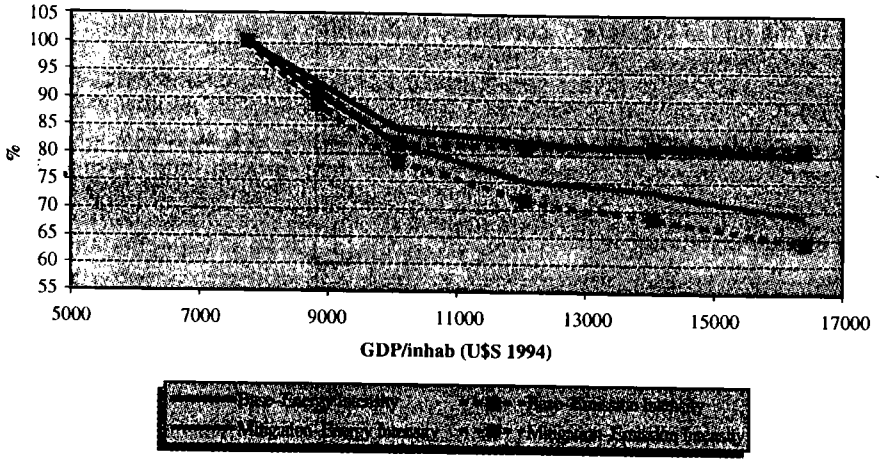
Gas Type	Units	Base Year	Mitigation Scenario 2005	2010	2020	Base Scenario 2020
CO_2	Gg	118190	138440	161860	223780	281660
CH_4	Gg	35.0	61.1	113.4	199.6	203.1
NO_x	Gg	684.1	824.1	1001.6	1463.4	1731.5
CO	Gg	1752.9	1622.9	1538.9	1437.5	2052.0
CO_2 Equiv.		151671	177767	209319	291517	362052

Even if mitigation actions are implemented the true differences between both Scenarios shall become more clearly evident after the year 2005. CO_2 total emission savings shall amount to 20700 Gg in the year 2010, rising to 58000 Gg in the horizon year. In terms of annual emissions expected in the Base Scenario, such savings would imply 11% reduction in the year 2010 and almost 21% in 2020. Total specific emissions would persist along a downward trend throughout the period under analysis, with a 7% decrease compared to present values.

To overcome the analytic constraints posed by specific emission per energy unit used as an indicator of environmental efficiency in the use of energy, the energy pathways and CO_2 emission were calculated for both Scenarios.

The energy pathway graphically represents the variations in domestic economic activity's energy intensity (energy offered per GDP unit) as a function of the economic system's evolution, measured by the per capita GDP. A similar curve can be drawn for CO_2 emissions, i.e. the emissions pathway, which represents the emissions' evolution per GDP unit as a result of changes recorded in the per capita product.

Energy and CO_2 emission pathways



Mitigation measures as a whole, would permit a reduction in the Argentine economy's energy intensity in the next ten years, 3% above the 16% considered in the Base Scenario. It is important to point out that such trends would materialize in an openly expansive economic activity, resulting in 30% increase in present per capita product.

In the longer term their impact on energy intensity would increase, adding a reduction of over 10 points to the drop considered in the Base Scenario. Compared to present values, energy intensity in the Mitigation Scenario would drop over 30% as a result of the combined effect of technological innovation, structural adjustment and the promotion of a higher energy efficiency.

As for total methane emissions, same shall originate mainly in final energy consumption sectors. In effect, future growth of CH_4 emissions shall be driven by the transport sector, whose share would persistently grow, to reach slightly over 97% in the horizon year, compared to the present 95%, values similar to those expected in the Base Scenario.

Differing from figures expected in the Base Scenario, the future evolution of NO_x emission shall be defined by two major sectors: transport and agriculture and cattle breeding, as the decrease in electricity generation by thermal power stations would largely reduce the share of electricity power plants in NO_x total emission.

The simultaneous decrease of NO_x emission in electricity power plants and in transport as a result of the decrease in the use of petroleum products, highlights the relevance of agriculture and cattle breeding in NO_x total emission in the Mitigation Scenario.

As for CO, mitigation measures in the transport sector shall result in a 34% reduction of the sectoral emission expected in the Base Scenario for the year 2020. Given transport's high participation in CO total emission, the global effect of such measures would be a persistent reduction of total CO volumes emitted by the energy system, which in the horizon year shall reach only 82% of present volumes.