Economics of Greenhouse Gas Limitations

Argentina

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TABLE OF CONTENTS

The climate change in developing countries

1 Introduction

A methodological approach to analyse climate change mitigation in Developing Countries (DCs) –as is the explicit goal of the GEF-UNEP project "Economics of GHG Limitations"- should go beyond identifying the main difficulties that arise in applying the IPCC methodology. The GEF-UNEP project is a good opportunity to comprehensively debate the IPCC approach and give new insights on how to face the climate change problem, thus contributing to the search of consensus in the international community.

From such perspective, some general comments are presented here-in-below about the implications of climate change mitigation in the DCs suggesting new issues that could help capture the growing difficulties DCs will face in the new international context. Chapter III identifies specific problems that arise when the methodology proposed is applied to Argentina.

2 Climate change: a planet concern

Although developing countries (DCs) are not required to undertake actions to mitigate greenhouse gases (GHG) emission in the near future, 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 world-wide. The fact that a growing number of DCs are signing or ratifying the United Nations Framework Convention on Climate Change and are now drafting their National Communications on GHG emission inventory, is a clear evidence of DCs growing awareness on the urgency to address the problem.

There is scientific consensus that the present global warming has an anthropogenic origin. However, broad uncertainty still exists in this respect. Controversial estimates about the same phenomenon, the complexity and duration of the processes involved, the ignorance on how climate systems work, scarce information, the limits of models and instruments used, are factors that prevent a true prognosis from being made.

Amidst this context of uncertainty the implementation —or non-implementation— of actions to mitigate climate change's eventual effects should be decided. Considering the potential significance of such impacts on the socio-economic system, the principle of caution should be applied in defining 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. GHG national inventories as well as vulnerability and adaptability studies are the result of this context.

As for vulnerability, apart from the initial concern on the impact of ocean levels' increase over coastal areas, we should add the effect of changes in rainfall on economic activities and the sustainability of settlements in different regions. Such aspect is

especially critical in the DCs, considering that the degree of vulnerability strategically relates to 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 a relatively short time the severity of the problem will no doubt call for an intervention to mitigate such effects. Passing from research and more knowledge on the phenomenon to action requires consensus in the international forums where DCs should have an active role to guaranty equitable decisions, considering both the impacts and the original contribution to the problem.

3 The impacts of mitigation

When discussing the impacts of climate change mitigation actions on the DCs, only the economic and social consequences of their own mitigation policies are considered. The methodological guides for mitigation studies in the DCs refer in broad terms to the type of impacts that should be considered, assuming that additional costs associated to such mitigation actions will be covered with GEF funds. However, some doubts exist on whether all the additional costs a country will have to incur in undertaking such actions are included, especially regarding distributive impacts.

Leaving aside the methodological difficulties to properly assess the costs of implementing a mitigation policy within its own borders, discussed in this report's Chapter III, it is worth to analyse the impacts of growing international restrictions on GHG emission on the DCs' economic development opportunities.

The potential damage of persisting along the present path of GHG emission is large enough to generate mounting claims from ecologist groups and is forcing governments to exhibit positive actions towards climate change mitigation. To the extent such actions focus on opposing industrialised countries' present consumption patterns, the international trade of certain products —vital to finance the development of DCs— could be affected.

It should be borne in mind that most of the fossil energy traded in the international market comes from developing countries and is burnt in industrialised countries. Although environmentally necessary, a drastic reduction in such products' consumption would have a substantial economic impact on energy-producing DCs, which as a result of their own characteristics would have some difficulties to restructure their economies in the short-run.

A similar situation could appear in the market of other energy-intensive products, especially basic goods such as steel and other metals, although in this case imports from industrialised countries could be an effective mechanism to ascribe the responsibility of GHG emission to exporting countries. After the second oil crisis, at the end of the '70s, a similar mechanism was used to reduce the industrialised countries' energy intensity, moving energy-intensive industries to DCs with a guaranteed energy supply.

Since globalisation showed the need for economic adjustments in industrialised countries, the idea that international trade should be somehow regulated to prevent unfair competition started to take root. Besides the World Trade Organisation (WTO) agreements, some voices started to demand that social and environmental aspects be considered in such regulations.

8

Almost all developing countries had to restructure their economies forced by the international context, which remarkably affected their domestic markets' capability to drive their economic development. Under the present circumstances their economic growth depends —and will depend— on their ability to penetrate developed countries' markets. Therefore, the conditions imposed by industrialised countries to open their markets to international trade are key to DCs' development.

Particularly environmental regulations on international trade could force DCs to accept climate change mitigation costs just to enter international markets and help overcome the deep social crisis in which economic restructuring have placed them.

Even if this context may make economic development more difficult to achieve, these comments are not aimed at arguing on the inconvenience of climate change mitigation actions, which according to all the analyses performed 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 allocating their costs.

4 Climate change mitigation: risks and opportunities

Although from the climate standpoint GHG concentration in the atmosphere is the key point, all debates on mitigation have only focussed on the future abatement of annual emission. The irreversibility of past emission, however, should not circumscribe the debate to the different countries' responsibilities on future increase in GHG concentration levels.

Actually, the proposed theoretical and conceptual approaches are based on models and criteria that fail to consider the contribution from each party to the problem, and rather seek the most attractive mitigation opportunities from the standpoint of cost. As methods recommended to appraise mitigation activities are strongly influenced by income distribution, the final result may lead to the paradox of prioritising the implementation of mitigation actions in areas having less responsibility in the creation of the problem.

Given the world-wide character of climate, it is important to attract all countries' voluntary action to abate future GHG emission and prevent DCs from adopting development patterns that have already proven their environmental non-sustainability. An effective limitation on GHG emission should call for deep changes in present consumption and production patterns. Even if industrialised countries made the main efforts to achieve such changes, the DCs would face the cost of maintaining the distressed living standards of a large part of their population as they would be unable to ensure an adequate growth pace of their economies under the new international context.

Undertaking the additional commitment of implementing mitigation actions within their borders would mean for DCs to increase the social and economic costs that would be supported unequally by social and economic agents. Under the present conditions of social fracture and economies' trans-nationalisation, DCs governments are loosing their power to ensure social equity in allocating mitigation costs.

Therefore, the assessment of the true costs of climate change mitigation should be closely related to considerations about equity. It could be argued that such problems correspond to domestic policy and are dependent on each government's ethical and political position. But it seems to us that equity considerations should be present in international debates, methodology guidelines and training courses, especially if they

are aimed at developing a consistent approach for mitigation studies in developing countries.

Likewise, the international negotiation process to seek commitments for climate change mitigation should progress towards an equitable allocation of mitigation costs among the international community. From such perspective, analysing the present situation and future expected evolution of net GHG emission in the various countries does not suffice. The historical responsibility in the creation of the climate change problem must be established, i.e. the responsibility in having reached the present GHG concentration levels in the atmosphere, and those to be reached in the next 100 years.

A serious debate is required on the extent of the historic period to be analysed, the appropriation of CO_2 sumps shared by the international community and the criteria to allocate emission between exporters and importers of GHG emission-intensive goods in international trade. Regarding the role of international trade in allocating emission responsibility, deforestation promoted by timber exports in certain DCs could be added to the already mentioned examples.

Clearly, mitigation cost will depend on the assumptions made on these issues, which will also define the basis for an equitable allocation of mitigation costs among the parties. From such approach, it is worthy to wonder whether the funding of DCs' incremental costs of mitigating future emissions corresponds to equity precepts. Or whether for the sake of equity some climate "assets" and "liabilities" should be assigned to each country depending on their historical responsibility for GHG concentration levels, which could be used to collect and assigned funds for future mitigation actions

In the specific case of Latin American countries, their historic contribution to climate change mitigation through hydroelectric development is internationally acknowledged. Less known however is the economic and social cost these countries have paid for their "environmental" contribution to the international community by funding such works with their own resources and short-term high-interest-rate loans granted by international private banks, which added to their foreign debt. It could be argued that such deleterious effects were enhanced by a certain inefficiency in fund management, however what cannot be denied is the international benefit derived from that capital allocation policy of Latin American countries to the detriment of immediate consumption and the economic welfare of their peoples.

In any case, just recognising the "environmental debt" does not solve the problem by itself. But a debate focused on CO_2 concentration in the atmosphere considering differences in past and present emissions will still evidence significant asymmetries with a greater responsibility of industrialised countries, even assuming drastic changes in future emissions. Recent analyses[1] show that the contribution of Annex I countries to global warming in the year 2096 shall be 30% higher than the rest of the world's, even assuming a 40% emission abatement in Annex I countries for the year 2016 and a 300% increase in the emission of the rest of the world for the same year.

Ethic and equity considerations were established by the Climate Change Convention, which in its Article 3 states: "...the parties should protect the climate system for the benefit of present and future generations on the basis of equity and in accordance with

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[1]   Pinguelli L., Kahn Ribeiro S., The Present, Past and Future Contribution To Global Warming COPPE/UFRJ, 1996

their common but differentiated responsibilities and respective capabilities ...". In implementing Article 3's prescriptions different notions of equity have been assumed: parity, proportionality, priority, utilitarianism and distributive justice. To begin with, equity means the right to an equal per capita emission level. But equity is a controversial point in the debate on GHG emission limitation, which demands certain basic principles to be borne in mind: all human beings are equal; all of them, also the poor, have equal rights over common goods, including the atmosphere. Sustainable development is impossible unless due attention is paid to the problem of poverty.

As can be seen, introducing equity considerations in climate change mitigation analysis would force to change the whole methodological approach and therefore it can not be omitted from a project like the "Economics of GHG Limitations".

International negotiations have been always characterised by the defence of each participant's economic interests and their results reflected the relative power of each party. But never before the interdependence of all countries has been as clear as in addressing global warming, a problem that affects all world inhabitants alike. This is therefore a unique opportunity to transcend national interests and collaborate in searching for effective and viable climate change mitigation actions.

As risks and vulnerability resulting from global warming have negative consequences for both industrialised and developing countries and, therefore, both groups should co-operate to solve the problem, it is impossible to choose a non-participating attitude. Some actions based on unavoidable ethical principles must be taken.

Diagnosis of the Argentine situation

1 Introduction

This chapter presents a brief overview of the socio-economic, energy and environmental context in which climate change mitigation actions in Argentina shall be inserted. To that end, the dynamic of the Argentine economic development, its influence on the energy system and environmental impacts is summarised. From the environmental standpoint, emphasis shall only be made on the impact of economic development patterns and energy policies on GHG emission.

2 The socio-economic context

To clearly understand the present expansive dynamics of the Argentine economy and contribute elements to judge its permanence in time, the following sections address the stages of the Argentine economic development and the evolution of major macroeconomic and social variables.

2.1 Argentine economic development: its stages

2.1.1 Primary export model

The integration of Argentina to the world capitalistic system, by the end of past century, was based on agricultural exports, using advanced technologies for that time, employing labor-European immigrants and making extensive use of very fertile soils.

Although this primarily exporting model resulted in a very significant GDP growth[2], it went hand in hand with marked differences in income and wealth distribution. These were specially linked to a strong concentration of land ownership and an unequal relation between population and export production chains. Ground rent, the major component of economic surplus, was distributed among few social sectors, and used to a large extent to purchase manufactured consumer goods from abroad.

In any case, both the protection coming from freight costs and the fast population growth in large cities led to a remarkable development of certain industrial activities. Thus, in 1929, when the growth model based on primary exports concluded, the Argentine industry had reached a GDP share close to 18%.

As a result of the 1929 crisis, the volume of exports and their prices experienced a sharp drop producing a marked distortion between domestic supply and demand. Drastic cuts in the country's import capacity gave rise to serious difficulties to meet the domestic demand of manufactured goods

2.1.2 Substitutive Industrialisation

After a transition period that lasted until the mid-Forties, industrial development notably increased on the basis of an import substitution process. During the first stage,

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[2] In 1929 the Argentina's per capita GDP reached about 40% of the US level, in spite of the fast population growth.

which lasted until the mid 50's, substitutive industrialisation focused on non-durable consumer goods (food and textiles), even though it also comprised certain widespread intermediate goods and low technological complexity capital goods.

The substitution of imports was not selective, and emerging activities enjoyed a high tariff protection. As a result of this industrialisation process, the composition of imports began changing, with a drop in the share of consumer goods and a rise in intermediate and capital goods.

In this stage, the expansion of industrial activities represented low investment thresholds and massive labour hiring. This industrialisation process was consequently developed together with an intense rural-urban migration, which reinforced population concentration in large urban centres, particularly the Greater Buenos Aires area. In 1947, around 30% of the country's population lived in this area.

The need to meet rising demands for infrastructure and public services (derived from rapid industrialisation and urbanisation processes) resulted in the establishment of State companies (creating new companies or nationalising existing ones), particularly within the energy sector. Rising State intervention was basically the response to private agents' weakness or lack of interest to meet new demands.

By the mid 50s Argentina had attained a considerable industrial development, as well as a degree of social equity which permitted most of the population to gain access to formal markets and to meet basic needs. However, recurring crises, which characterised substitutive industrialisation throughout the following period, emerged within the foreign sector. From there onwards, Argentina's social and economic development was affected by mounting social conflicts which resulted in a marked political instability, due to a strong balance among the different social and economic groups.

By 1960 industrial share in the GDP had reached nearly 24%, although some 50% of the value added in manufacture came from the production of non-durable consumer goods (see Table 1).

Successive distortions in foreign accounts reinforced substitutive industrialisation in the field of intermediate and durable consumer goods, and capital goods. This industrialisation stage was characterised by a strong and growing participation of transnational companies. Adopting technologies used in industrialised countries to supply the small-size local market —still indiscriminately protected— turned local industrial markets into oligopolies.

On the other hand, the equilibrium of Balance of Trade still rested on traditional exports since nearly all manufactures (specially durable, intermediate and capital goods) were meant for the local market. In addition, profit-remittance from multinationals' branches to their head offices increased the negative balance of income transfers, and placed at greater risk the situation of the Balance of Payments.

In any case, the 60s were one of the more active periods in Argentine economy especially driven by industrial growth, which in such decade reached an average annual rate of 5.6% against 4.2% of the GDP.

Table 1 clearly shows changes in the structure of the GDP and the value added in manufacture as substitutive industrialisation became stronger. While the industry's share in the GDP rose from 23.6% in 1960 to 27% in 1970, there was also an increase in

14

the production of intermediate goods (specially chemical, petrochemical and basic metal industries), durable consumer goods and capital goods.

Table 1   Evolution of GDP and value added in manufacture 1960-1995 (%)

Year	GDP c.a.r. (*)	per capita GDP c.a.r. (*)	Evolution of the industrial sector				
			Value added in manufactures c.a.r. (*)	Industry's share in GDP (%)	Industrial structure (%)		
					Non-durables (**)	Intermediate goods (***)	Durable and capital goods (****)
1960	3.0	1.3	4.3	23.6	48.7	29.3	22.0
1965	4.4	2.8	6.4	26.0	42.8	33.4	23.0
1970	4.0	2.5	4.8	27.0	39.0	36.3	24.5
1975	2.9	1.0	3.4	27.8	39.0	35.5	25.5
1980	2.2	0.5	.0	24.8	36.0	35.3	28.7
1985	-2.1	-3.5	-4.0	22.5	37.4	40.3	21.6
1990	0.0	-1.4	-1.7	20.7	40.4	42.5	17.1
1995[(3)]	5.3	3.7	4.7	25.3	38.3	39.4	22.2

(*)   c.a.r.: cumulative annual rate of the previous 5-year period
(**)   Foodstuff, beverages & tobacco, textiles & leather, wood industries
(***)   Paper & printing material, chemical, non-metallic minerals and basic metal industries.
(****)   Metal, machinery & equipment industries.

Source: FIDE "Coyuntura y Desarrollo", several issues and BCRA (Central Bank of Argentina).
              Cuentas Nacionales de Oferta y Demanda Globales 1980-1995 - MEOySP

Within a context of fast international economic growth, Argentine exports grew at a steady pace as of the beginning of the 60's and until the 70's, while imports were still strictly controlled. Thus, positive trade balance lowered foreign debt constraints during such period.

By the end of the 60's, however, the symptoms of a new crisis in the accumulation process became evident, while social and political tension mounted and inflation grew higher. Conflictive expectations of the social groups powerful enough to influence economic policies accounted for the political tension. The main disputes were on national control over the accumulation process, the extent and methods of State intervention in the economy, and on aspects related to social equity. But the industrialisation process as the driving force of economic development was never questioned until 1976. Proposals to deeply change the role of the State as public service provider by investing in infrastructure and producing certain basic inputs had not prevailed until that time. At the same time, the State rapidly lost its power to settle and mediate in social conflicts, and this weakening of the State's role intensified the economic decay. It can be stated that by mid '70s the crisis of the substitutive industrialisation model became evident.

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[3]   Corresponds to the 1986 prices GDP series. It should be highlighted that the industrial structure calculated on the basis of the new GDP series at 1986 prices exhibits significant differences with data appearing in the table for 1980, 1985 y 1990. In effect, for such years values read as follows:

Year	Non-durable goods	Intermediate goods	Durable goods
1980	32.8	37.7	29.5
1985	38.5	35.8	25.7
1990	40.9	39.3	19.8

Although magnitudes differ, a similar trend can still be noted.

2.1.3 Stagnation and foreign indebtedness

The economic, social and political crises, at the beginning of 1976, paved the way for the military to take office. Their economic policy aimed at a deep restructuring of the economy and the role of the State, and strongly challenged the previously adopted industrialisation model as well as concurrent social and political structures. To that end, the new government gradually opened up the economy to foreign trade, granted absolute freedom to the financial sector, assigned a subsidiary role to the State and tried to weaken workers' trade unions.

The opening-up of trade as of 1978, rapidly intensified due to a simultaneous slippage in the adjustment of exchange rates, resulted in a drastic discrepancy between domestic and foreign prices, which deeply affected industrial activity. Consequently, the value added in manufacture dropped 23% between 1979 and 1982.

Financial liberalisation put into practice as of 1977, within a highly speculative local context and strong liquidity at international level, promoted a swift rise in foreign debt that was not aimed at expanding productive investment. The foreign debt rose 270% between 1977 and 1982, while the GDP fell 6.7%, and no significant changes were recorded regarding gross domestic investment until 1980, when a downward trend began.

The subsidiary role of the State brought about an increase in transfers to private economic groups through unfair contracts. Other transfers originated on direct subsidies and on the drop in the real level of State-owned companies' rates and real wages. Thus, the non-financial current budget deficit tripled between 1977 and 1982. This deficit of the State and its companies was covered through short-term foreign and domestic loans. Such indebtedness represented an additional way to transfer wealth to private economic and financial groups, which gave origin to the so-called quasi-fiscal deficit.

All these policies resulted in a drastic squeeze in the domestic market. Thus, exportable surplus increased, regarding both primary production and manufactured goods. Stagnation, inflation and foreign indebtedness were the main features of this period.

2.1.4 The weakening of the State

When the financial capital inflow stopped in 1981 due to international liquidity conditions, the distortions in foreign accounts originating in the strong short-term foreign debt became evident. The private sector's share in that year's total debt reached 43%. Successive currency devaluations seriously deteriorated the financial situation of indebted private companies. Therefore, the government decided to nationalise their debt, thus transferring wealth and income to private economic groups once again.

By the end of 1983 the new constitutional government found the Argentine economy running within a narrow channel between suspension of foreign payments and domestic chaos. The economy was featured by: distorted financial market —with high interest rates and marked speculation—; a virtual state of hyperinflation; strong distortions in public accounts; massive wage demands and a strong economic concentration in the hands of few highly-diversified economic groups.

Within this framework, the operative margin for the economic policy was quite low, and the initial attempt to introduce changes in relative prices and distribution variables resulted in a boom of inflation rate (See Table 2). Consequently, with the exception of a

short-lived stability resulting from an adjustment plan implemented by mid 1985, the above-mentioned macroeconomic characteristics persisted.

Table 2   Evolution of the inflation level, real wages and foreign accounts

Year	Wholesale prices' annual rate	Average real wage 1980=100	Balance of current account (in million US$)				Foreign debt in mill US$ (*)
			Exports	Imports	Balance of trade	Current account balance	
1970	26.8	141.0	1773	1694	79	-156	3875
1972	76.0	133.6	1941	1905	36	-223	5092
1974	36.1	152.7	3931	3635	296	127	5514
1976	386.3	100.1	3916	3033	883	649	9738
1978	143.3	81.3	6399	3833	2565	1884	13663
1980	57.5	100.0	8021	10541	-2519	-4768	27162
1982	311.3	80.8	7624	5337	2287	-2357	43634
1984	625.9	115.3	8107	4585	3522	-2391	46171
1986	57.9	96.7	6852	4724	2128	-2859	51422
1988	431.	89.9	9134	5322	3812	-1572	58336
1990	798.4	74.4	12353	4078	8275	-4552	61770
1991	56.7	70.6	11978	8275	3703	-672	63172
1992	3.0	70.2	12235	14872	-2637	-6677	62500
1993	1.6	68.4	13118	16784	-3666	-7568	78547
1994	0.7	s/i	15839	21590	-5751	-9309	90014
1995	7.8	s/i	20963	20122	841	-2277	103818

(*)   End of the period

Source: FIDE "Coyuntura y Desarrollo", several issues.

The GDP showed a downward trend during the 80's. This resulted in a 22% drop in the per capita GDP (See Table 1). Value added in manufacture recorded a sharper fall, while its structure also changed. The squeeze of industrial activity strongly impacted the production of durable and capital goods (55% drop).

Although basic industries started exporting as of 1985, world markets for such products were already evidencing crisis symptoms. In spite of the rise in exports as well as a drastic cut in imports, the balance of Current Account remained negative between 1984 and 1989 (Table 2) due to the payment of foreign debt's interests, which reached some US$ 5000 million per annum during 1984-1989 period. The payment of foreign obligations simultaneously affected Foreign Accounts balance and the public sector's financial situation, which got caught between local and foreign creditors.

The progressive worsening of this situation and the State's extreme inability to overcome it resulted in a state of hyperinflation towards mid 1989[4], which forced the change of government before the scheduled date.

2.1.5 State reform and economic restructuring

The economy restructuring in Argentina started with measures implemented by the military government in 1977/78 (commercial opening up, financial reform and subsidiary role for the State). Nonetheless, distortions and especially the foreign debt caused by such measures paved the way for the possibility of intensifying the reform.

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[4]   Wholesale prices' movements reached 5,386% that year.

The restriction imposed by foreign indebtedness during the 80's was the main axis for economic restructuring. Such reforms was characterised by three main features, which were gradually emphasised, namely:

- higher economic globalisation through commercial and financial opening up;
- turning the economy back to its previous specialised profile, making it dependable on the export of both agricultural or agroindustrial goods and low value added raw materials such as oil;
- State withdrawal from the production of goods and services.

After an initial period in which the crisis symptoms persisted[5], at the beginning of 1991 the new constitutional government applied an economic program to deepen this economy restructuring through:

1. Price stability based on a fixed exchange rate implying full and free convertibility vis-à-vis the US dollar;

2. Deregulation and liberalisation of the domestic market through rapid tariff reduction;

3. State reform, including the swift privatisation of public companies, the rationalisation of expenditures, the recovery of tax-collecting capacity, and the transfer of certain basic social services to the provinces.

Convertibility became a key instrument for price stability, and there were several reasons to account for this role. Firstly, it prevented to resort to currency devaluation and consequent changes in relative prices for capital formation. Secondly, because in an open economy the fixed exchange rate forces domestic prices (of tradable goods) to be in line with international ones. Finally, because the establishment of the "dollar standard" no longer allows for the manipulation of money supply, which remains tightly tied to the Balance of Payments.

So far, this plan has proved effective to cut inflation down, both rapidly and radically. Wholesale prices' annual movements stabilised at around 3% as of the plan's implementation (See Table 1). Nevertheless, consumer prices' movements were significantly higher (around 18 to 20% per year up to 1993). Higher stability, tied to a drop in interest rates on loans, led to a reactivation of the economy between 1991 and 1992, with an annual growth rate of 8.8% for the GDP and 9.6% for the value added in manufacture.

Industrial sectors producing durable and capital goods enjoyed a higher reactivation[6]. Economic reactivation was mainly fuelled by the demand of consumer goods, especially durables. The demand of capital goods had a low share in this reactivation process.

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[5]   A new hyperinflationary episode took place between the end of 1989 and the beginning of 1990, although shorter and less intense than the previous one.

[6]   During the first year of the convertibility plan (March 91-March 92), both sectors' production movements were as follows: Durable goods: 156%; capital goods: 126%. It should be pointed out that such percentages result from very low previous levels. Production movements related to intermediate and non-durable goods were quite lower (6 and 11%, respectively).

The opening up of the economy, fostered by the progressive currency appreciation resulting from a fixed exchange rate, favours the economy re-primarisation: only primary goods and an extremely limited range of highly specialised manufactured goods are capable of preserving their competitive advantages under such conditions. The growing competition of imported manufactures is clearly reflected in the evolution of the Balance of Trade[7]. Imports gradually substituted domestic supply, specially manufactured consumer goods[8].

State reforming has been made especially dependent on the debt restructuring with foreign creditors. When passive money supply conditions prevailed, the service of the foreign debt required a primary surplus in public budget. To achieve such surplus, three main lines of action were followed:

- an increase in tax collection (tax reform),
- the transfer of public companies to the private sector (privatisations), and
- a rearrangement of activities in the hands of the State (expenditure rationalisation).

Medium and long-term prospects of the plan is quite uncertain due to the number of domestic and foreign conditions required to make it feasible, namely:

1. microeconomic adjustment to achieve a higher external competitiveness, within an overvalued local currency context;

2. permanent capital inflow to offset distortions in the Balance of Payments;

3. low interest rates in international market to allow for such capital inflows;

4. expansion of domestic markets to allow capital inflows;

5. expansion of domestic markets to increase tax collection once the privatisation process is completed (against a squeeze in real wages);

6. growing exports in order to control the Balance of Trade.

The observance of the schedule for regional integration within the Mercosur implies a further challenge for the current economic plan, specially considering the asymmetries evidenced by the most important partners' economic policies. The main goals sought by the integration process are:

- to maximise the opportunities offered by the regional market to producers from the four member countries;
- to promote technological, productive and commercial co-operation and complementation in order to gain access to extra-regional markets.

Existing possibilities are undoubtedly significant regarding both aspects. However, obstacles are also considerable. Differences in the social and economic conditions of the four member countries are notable, as well as serious difficulties to co-ordinate macroeconomic policies. Moreover, significant differences exist regarding incentive

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[7] The Balance of Trade went from US$ 8.275 billion in 1990 to US$ 3.703 billion in 1991 and US$ -2.872 billion in 1992.

[8] The share of consumer goods in total imports reached 21% in 1991 (4.6% in 1985), displacing intermediate goods.

policies for productive activities and regulation of public services (energy, communications, transport, etc.).

2.2   Demographic aspects

In 1995 the Argentine population amounted to 34.6 Million inhabitants, over 87% of which lived in urban centres (towns with over 2,000 inhabitants).

According to the census, the average population growth between 1980 and 1991 was only 1.41% per annum. According to such records, there was a sustained slowing down of population growth rate, starting after World War II when the European migration wave that largely accounted for the expansion of the Argentine population as of the end of last century was interrupted. Official projections forecast a future decrease in the population growth rate to 1.35% per year.

As previously mentioned, the country's early industrialisation process favoured internal migrations towards urban centres, thus accounting for the high urbanisation level attained. Such process was however uneven in the country. Industrial activity concentration in the central area of the country (Buenos Aires, Santa Fe, Cordoba and Mendoza) promoted the establishment of large urban centres in this area, which in 1991 concentrated over 73% of the total urban population.

The most extreme case is that of the Federal Capital and surroundings, where about 34% of the total population are settled. Although the spatial concentration is not new[9], in the last years an early trend towards de-concentration, witnessed between 1960 and 1980 seems to have reverted. Modifying the population's spatial distribution in the future would call for active policies to retain population in the different peripheral areas and promote the growing relocation of production activities. The fact that the project to move the capital city has been abandoned, as well as subsidies to regional economies, leads to believe that in future no substantial changes will occur regarding the settlement of land.

The low population growth is also affecting homes' average size, which records a slight downward trend and reaches 3.8 persons/home according to the 1991 census. The national average clouds, however, significant regional differences. While in the metropolitan area the average is 2 persons/home, in some northwestern provinces such figure rises to 4.7 persons/home.

As regards urban jobs, the economically active population grew as of 1991, reaching 41% of urban population versus a previous value stabilised in around 38%. Several reasons account for such increase.

Firstly, between 1991 and 1995 an important change occurred in the employment structure, with low job opportunities and the elimination of many traditional jobs in the industrial, trade and basic services (electricity, gas and water) sectors. This resulted in increased employment offer by the family group as a survival strategy. Secondly, the overvalued local currency induces a nominal salary increase expressed in foreign currency, which renders more attractive the search of a second or third job both at family and individual level. Lastly, the nature of changes in employment and the new guidelines in place favour a higher rate of women jobs. This set of factors accounts for the change in employment supply in almost 3 points over the total population.

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[9]   In 1947, 29% of the country's total population lived in the metropolitan area.

In summary, Argentina presents demographic features which to a large extent resemble those of more developed countries. Especially when considering the low population growth rate, high urban concentration and the relatively high degree of women employment. In the last years greater flexibility has been witnessed in the employment supply, caused by productive restructuring.

Argentina shares, however, less or little developed countries' features: high population numbers with basic needs unmet; acute urban population concentration in very large urban centres and a considerable disparity in quality of life both between countryside and cities, and between the metropolis and a substantial part of the provinces.

2.3   Economic growth

As has been described before in Section 2.1, the Argentine economy was affected by cyclic recessions between 1974 and 1990 (see Table 1) resulting in deep structural changes which have become evident in the last 6 years. This section will focus on analysing changes in productive activities, while the recent evolution of other macroeconomic variables that might affect the future dynamics of Argentine economy will be discussed in subsequent sections.

According to official estimates, the overall economic growth between 1991 and 1994 amounted to 7.4% per annum, which permitted to recover the 1980 per capita GDP. In those years economic activity was favoured by prices' stability and foreign capital inflows, as well as by the public sector's financial relief as a result of public companies' privatisation.

However, by the end of 1994 latent imbalances started to become evident. Such imbalances deepened because of the flight of foreign funds as a consequence of the Mexican crisis, resulting in a recession that lasted until mid-1996. The shrinkage in domestic consumption during this period exceeded the drop in GDP, estimated in 4.4% in 1995 and 3.2% in the first quarter of 1996, due to a remarkable increase in exports (see Table 2). Although indicators have evidenced a production upswing since mid-1996, as will be discussed in subsequent sections, the domestic market recovery shall be noticeably slower due to the loss of population's purchasing power, caused by strained employment conditions and high unemployment rate.

From a global standpoint, the Argentine economic structure has followed the same trends as most countries in the last decades, i.e. towards a greater participation of tertiary and basic infrastructure sectors, at the expense of primary and secondary sectors which in 1994 accounted for 42% of the GDP. Particularly, the share of industry decreased from 28% in 1980 to 24% in 1995.

Some studies suggest that the actual drop in the industrial contribution to GDP would be even greater if changes affecting the relative prices of manufactured goods since 1986, base year of the national accounts' official series, were taken into consideration. Besides the distortions that changes in relative prices might introduce, it should be pointed out that severe discrepancies exist in the series of physical industrial production for the last 6 years, depending on the agency in charge of the estimations.

Cyclic recession affected industrial branches in different ways, depending on the activity's transnationalization degree, its actual exposure to foreign competition, the impact of exchange rate fluctuations on production costs, the incorporation of new technologies and its insertion in international markets.

Thus, the only branches for which value added in 1995 exceeds that of 1970 are: foodstuff, beverages and tobacco; paper and paste; chemical products in general; rubber; glass; cement; non-ferrous metals and electric machinery.

However, when activity rates are presented per inhabitant and according to their average values (1970/80; 1981/90; 1990/95) it appears that only a few branches evidence a higher rate in the 1990-95 than in the 1981-90 period and practically none a rate higher than that recorded for 1970-80.

Following the ISIC Revision 2 international code, only branches 311/12 (foodstuff), 341 (paper), 352 (other chemical products) and 383 (electric machinery) evidence higher average rates in the 1990-95 period than the previous decade average. Additionally only branch 351 (chemical products) evidences a higher rate in 1990-95 than that of 1970-80, although the former level is lower than the one reached in the previous decade.

A more detailed comparison of the value added in manufacture and its internal structure for the major sectors reveals the impact of policies implemented in the last 20 years on that sector. In the '80s the only sector that evidenced a steady growth was the food industry. The remaining subsectors evidenced negative rates, except for textiles, chemical and petrochemical products and basic metal industries, with positive rates for the 85/90 five-year period.

By 1990 a substantial change could be noted in the structure of value added in manufacture by large sectors, as a result of their different dynamics. Thus, the food industry (the most dynamic) moved from a 20% share of the value added in manufacture to 25%; whereas machines and equipment dropped from 29% to below 19% and textiles rose from 11% to 14%. On the other hand, basic metal industries recovered from their drop in the 80/85 period and reached a share of over 5% from slightly over 3% in 1980.

After the serious stagnation of the 80/90 period, a recovery of the activity level begins in 1991/92, which implies average industrial growth rates of 4.7% per annum in the 1990/95 period.

However such growth was not equal in all subsectors. The most dynamic was paper (10.4% average annual growth rate in the period), followed by basic metal and equipment industries (around 6.6% per annum). High rates are also noted in the chemical products and non-metallic minerals sector (4.5/5.5%). Conversely, the textile industry exhibits negative rates, and the activity level drops 1.2% per annum in the 90/95 period.

These industrial changes are relevant in building future socio-economic scenarios for this project, considering differences in energy intensities and the expected behaviour of energy-intensive activities (paper, chemical products, basic metals).

2.4   Employment and income distribution

2.4.1 The general trends in employment

Structural changes in the Argentine economy and the changing macroeconomic environment were strongly reflected on employment, regarding both size and structure. The 1980-1990/91 period was characterised by a relative growth of employment, at least proportional to the increase in labour supply. In such sense, overt unemployment did not grow after 1981, although figures exceeded those of the '70s.

However, the '80s featured strained employment conditions as industrial jobs dropped and the increase in informal and self-employment occurred at the expense of formal and hired employment.

The unemployment rate moved from almost full employment in October 1980 (2.5%) to 6 to 7% until practically 1992, inclusive. The under-employment rate grew from 5.8% in October 1980 to between 5 and 9% until 1991.

Available data reveal that most of the new jobs between 1984 and 1991 originated in the public and services sector (48% of the total) while trade contributed about 33.6%, i.e. over 81% of total jobs were created in such sectors. Industry, agriculture and construction only provided about 14% of the new jobs created in those 7 years.

The reasons, no doubt, relate to the above-described macro-economic context. Thus, after 1980, financial speculation and industrial destructuring led to a relative production decrease. However, the foreign debt and exchange rate increased industrial exports thus preventing a more drastic drop in employment.

The economic policy shift initiated by 1990 had a strong impact on the level and structure of employment. Although the industry recovered from the 1989/90 recession, its labour demand decreased due to technology renewal and the international integration of production.

According to estimates, the industry cut down between 210,000 and 350,000 jobs in the 1991-1995 period. The business sector laid-off about 25% of the above mentioned figures. On the other hand, transport and communications and the financial sector absorbed a number of people equal to those laid off by the remaining sectors.

Thus, practically no jobs were created between 1991 and 1995. This fact, together with an increase in the population's labour force participation rate, resulted in an unemployment level unmatched in the last 6 decades. Considering that Argentina should create between 190,000 and 210,000 annual jobs to maintain the unemployment rate stable, the non creation of new jobs led to an overt unemployment rate of over 17% in May 1995, compared to 7% in 1991. Based on such calculations it could be concluded that the non-creation of jobs and the increase in labour supply have generated about 1 million jobless each during the last 5 years.

2.4.2 General trends in income distribution

Data available about income distribution seem to evidence two apparently contradicting phenomena, difficult to explain on the basis of the data used.

The first one refers to the concentration of wealth in a context of very low total income growth, i.e. a substantial worsening of income distribution from the mid-70s to date, peaking by 1989/91.

According to the 1974, 1986, 1989, 1991 and 1994 income measures, the most regressive situation presumably appeared in 1989 when 20% of the lowest income population received only 3.8% of the total income versus 6.6% in 1974. By 1994 a slight improvement took place, reaching 4.8%. The growing concentration of income in the last quintile (highest income) reflects in the growth of its share from 42% in 1974 to 52% in 1991 and 50% in 1994.

The evolution of available income in each income class (quintile) shows that only the richest 20% of the population increase their income, whereas the remaining classes were worse in 1994 than in 1980, but better than in 1986.

Surprisingly, the number of homes with basic needs unmet (BNU) dropped in the same period. According to data from the census, between 1980 and 1991 the percentage of homes with BNU decreased in the whole country and this phenomenon occurred in most of the cases despite a reduction in the per capita GDP.

This seems to evidence that strategies existed to mitigate extreme poverty (by families and/or the government) in spite of the regressive distribution and the drop in GDP, besides the out-of-phase effect of social public spending of the '70s. (A. Abaleron, FB/1996).

From its size it should be assumed that all the population having basic needs unmet concentrate almost wholly in the first quintile and in some cases in part of the second. It should be noted that even in the metropolitan area, BNU homes were close to 15% and in many provinces they exceeded 20% (in some 30%). This situation will probably have worsened as of the end of 1994 due to high unemployment.

2.5 Prices, salaries and rate of exchange

2.5.1 Inflation in Argentina

The inflation rate in Argentina has been high since 1975 and even more so during the whole '80s. Consumer prices increased over 380% annually between 1980 and 1985 and around 486% per annum between 1985 and 1991. In 1989 the inflation rate exceeded 3000% and in 1990 it rose above 2000%. Only in 1991 the inflation rate decreased to more manageable figures of 172% a year. As of 1992 the rate decreased slowly to its lowest levels ever, around 4% a year in the 1994/1995 period and almost zero in 1996.

These price movements have not been alien to the economic context described in the previous sections. During the '80s inflation can be accounted for in terms of the ferocious intersectoral distributive struggle and the permanent excess in public expenditure caused by the service of the domestic and foreign debt. The currency issuance was in such context, both cause and effect of inflation. As noted, such situation strongly impaired the real wages and led to a regressive income distribution.

As of 1991, through currency convertibility, inflation dropped drastically but is still high in terms of a exchange rate that overvalued local currency from the very beginning. However, positive impacts of both monetary stability and growth on income distribution only lasted until 1994, as already seen. From the end of 1994 to 1996, recession and unemployment generated, in turn, a more regressive pattern.

2.5.2 Real wage evolution

Although either official or private real wage surveys stopped in September 1993, many indications hint that the real wages have been strongly impaired as of that year. Two reasons account for this: no salary adjustments in an inflationary environment and the drop in salaries resulting from the high unemployment rates (unemployment + underemployment rose from 18.7% in May 1993 to 29.7% in May 1995 and remained unchanged in April 1996).

Existing estimates show that real wages with base in 1980=100 had an average value of 138.7 between 1970 and 1976; of 90.5 between 1977 and 1991 and 73.2 between 1990 and 1993. In each of such periods the real wages' index fluctuated but the variability ratio for the 1970/1976 and 1977/ 1991 periods was 13% in both cases whereas it is only 2.4% between 1990 and 1993.

These data prove that the worsening of income distribution was tied to the inflationary process and to the impairment of real wages since the mid-'70s. However, data also show that monetary stability did not significantly improve real wages, initially frozen at the impaired 1990 levels and then, it is suspected, additionally impaired by unemployment and the erosion caused by inflation in the absence of positive wage adjustments. Undoubtedly, lower salaries were more affected by such process, although probably the highest salaries have increased, especially in the 1990/1993 period.

Convertibility has meant a strong currency appreciation in terms of retail prices. Therefore, even when the domestic purchasing power of real wages is one of the lowest in the Argentine history, it is high in nominal current dollars and above developing countries' average, although below the levels of the developed world.

This situation could account for both the domestic market downturn and the difficulties to improve external competitiveness in terms that exceed the present level. The discussion on how real wages' reduction in the present convertibility context might improve Argentina's economy competitiveness has not yet reached a conclusion, although doubts exist that this factor alone may suffice to attain such goal.

It should also be considered that every additional decrease in wages, whatever the means used, could increase the risk of macroeconomic instability, on account of the complex interrelations existing between relative prices, overall economic activity and the capacity to meet domestic and foreign obligations.

2.5.3 The exchange rate evolution

Along history, policies to moderate imbalances in foreign accounts originated substantial fluctuations in the exchange rate, which tended to overvaluation in periods of indiscriminate opening up of the economy, as proven by the evolution of real parity exchange rate at the end of the '70s and since 1991 to date.

Adjusting the exchange rate by the consumer price index, base 1986=100, the 1980 real parity exchange rate was 44% of the 1986 value, and in 1995 it amounted to only 41%. Such values notably differ from those recorded during the 1989 hyperinflationary crisis, when the real parity exchange rate reached to 169%.

It is important to point out that, conversely to what happened at the end of the '70s, consumer prices' evolution in the 1990/1994 period has been quite higher than that of wholesale prices, supposedly due to the increase in the cost of services. Therefore, real parity exchange rate, in terms of wholesale prices index, amounted in 1995 to 77% of the 1986 values.

This difference in price indexes also explains, as will be seen, the rise in imports while exports maintained at reasonable levels. This means that the effect of currency appreciation was felt more in imports than in exports. However, this has mostly been due to the fact that Brazil (and the rest of Mercosur countries) has also adopted policies producing currency appreciation, especially since the end of 1994 in the case of Brazil. This has permitted Argentina to eliminate its balance of trade deficit in 1995, but future results will depend on simultaneous adjustment in these countries.

Anyhow, the net balance of trade fits better to fluctuations in the real parity exchange rate estimated on the basis of consumer prices rather than from wholesale prices' index. Since 1970 Argentina has had a favourable trade balance with foreign countries except when the real parity exchange rate lagged behind.

Statistically, the Current Account balance fits worse the real parity exchange rate, because exchange rates that favour exports are usually linked to higher international interest rates (relative liquidity squeeze in the international market), easing the flight of domestic capitals and sterilising foreign savings in terms of the domestic investment potential.

2.6   The foreign sector

It has been stated in the previous section that the exchange rate has affected the foreign sector behaviour in a number of ways. The evolution of imports, exports and the Current Account balance shall now be analysed as well as the behaviour of the foreign debt in this complex environment of changes in the domestic and international macroeconomic context.

2.6.1 The evolution of imports

Argentine imports fluctuated between 4,000 and 5,000 million current dollars during most of the '80s in which, as seen, a protectionist environment prevailed. Such circumstances were caused directly by the tariff and prohibitions policy and indirectly by a slightly overvaluation of domestic currency.

Towards 1991 imports started to double and in 1995 they were fivefold those of 1990 (see Table 2). This resulted from the opening up plus the exchange rate lag and the arrival of capitals to fund it all.

Imports peaked at 21,600 million dollars in 1994, dropping to 20,000 in 1995 due to the 4.4% drop in the GDP. In 1996 the results of the first quarter slightly exceeded the figures for the same 1995 period in spite of a similar or lower activity level. It should be pointed out that of the total Argentine imports, 22% originated in the Mercosur, mainly in Brazil.

2.6.2 The evolution of exports

During the last decades Argentine exports showed a growing trend. In current dollars, Argentine exports moved from 7,000 - 9000 million between 1980 and 1988 to close to 12,000 by 1990-1992 and to 16,000 in 1994. An overvalued exchange rate in Argentina's major Mercosur purchaser raised exports to almost 21,000 millions in 1995, trend still visible in early 1996.

Of 1995 total Argentine exports, one third corresponded to Mercosur (81% to Brazil within the Mercosur total) and in 1996 such figure reached 34%.

2.6.3 Results of foreign trade and the foreign debt

Argentina's foreign sector evidenced an acceptable balance until the mid-Seventies. As of then and especially in the first years of the '80s severe commercial and financial imbalances became evident. During almost all of the '80s Argentina had negative balances in its Current Account in spite of positive commercial balances with foreign countries.

When analysing the evolution of Current Account balance and the annual increase in foreign debt it is noted that strong domestic currency appreciation periods coincide with significant annual foreign debt increases, above those required to offset negative balances.

26

The statistical analysis between both variables shows that the accrued balance of Current Account explains about 60% of the Foreign Debt variation, whereas the trade balance only accounts for 32%; both of them for the 1970/1994 period.

Given the 13,500 million US$ increase in reserves during the Convertibility Plan (1989/1995), this analysis was repeated including reserves' variation in the Current Account balances. In this case almost 76% of the Foreign Debt variation is accounted for.

Considering that additional income from privatisations in 1990-1996 period were not included in Current Account balances, it might seem that indebtedness exceeds the levels required to balance the foreign sector's deficit and reserves increase, which indicates the existence of other financial movements originating in the public and private sectors.

Argentina's foreign debt, expressed in 1995 US dollars, went from under 3,900 million dollars in 1970 to over 27,000 million dollars in 1980 and according to data from private sources such debt presently exceeds 103,800 million dollars. This means that the debt has grown at an average 13.5% annual rate between 1970 and 1996.

Presently the Foreign Debt represents about 39% of the GDP, similar to the 1984 value, but lower than the 1980s average. Considering that this ratio tends to decrease when the domestic currency is overvalued as at present, the 1992/1995 growing trend is concerning. To illustrate the influence of the exchange rate on this indicator suffice it to say that the Total Foreign Debt/GDP ratio went from 179 in 1989 to 58 in 1992 in spite of the booming growth of the debt.

Exports presently account for 20% of the foreign debt, one of the historically highest in Argentina. Likewise, the reserves/debt ratio has remained high since the Convertibility (undoubtedly a pre-requisite for this type of policy).

2.7   Conclusions

Argentina, in spite of its difficulties and conflictive social environment managed to grow at a sustained pace until the mid-'70s and practically until 1978/80. However, changes in the international macroeconomic situation and the domestic policies applied since then led to an extended global stagnation, even to a drop in the per capita GDP and in basic production.

Even when practically all Latin American economies were negatively affected by the Foreign Debt crisis in the 80s, Argentina evidenced greater instability and regression than the continent's major countries. Most of Argentine public and private debt originated in financial speculation, while in other cases indebtedness came from foreign investment in expanding local production.

Public policies in the '80s were characterised by attempts to stop the flight of capital, obtain income to pay the debt service and stop unemployment originating in both less industrial activity and the absence of an ongoing and harmonious growth. Within such framework the State became the only borrower of loans for which very high interests were paid, and this, together with the impossibility to further squeeze expenditures led to a permanent overspending of the public budget.

Consequently, currency issuance was both cause and consequence of the Argentine chronic imbalances, which became apparent through an acute inflationary process.

This way of facing the economy finally collapsed in 1989 leaving the country in a very adverse productive and distributive situation.

The new economic model implemented as of 1990 and consolidated between 1991 and 1993 was based on restructuring the previous financial system, aligning local currency with the American dollar, privatising practically all the public companies and addressing a greater opening up of the economy.

The massive capital inflows and the additional income from privatisations permitted to reactivate the economy from the very depressed 1989/1990 levels and increase public expenditure. However, the government used this additional funds to cover operating costs and the so-called "social expenditures", which are mainly devoted to support the Pension System.

By the end of 1994 the model known as "Convertibility" started to evidence certain flaws. The adopted exchange rate together with the opening up of the economy favoured imports, and so a substantial portion of the industry was prevented from recovering from the 1989/1990 crisis. The drop in industrial activity —together with the laying off in privatised companies' staff— resulted in higher unemployment, to which changes in labour demand and supply also contributed.

This intensified the recession and public income also started to suffer, in spite of the stronger taxing pressure. Public sector surpluses, attained in the first years in overvalued currency, turned into growing gaps. The government's latest measures tend to increase indirect fiscal pressure through collections in captive markets, but total expenditure adjustment seems difficult amidst recession and unemployment.

A recovery from the present situation seems complicated although it is undoubtedly tied to larger productivity in the modern sector, integrated to world markets through Mercosur. One of the questions and challenges is whether this mechanism will equate growth in exports and domestic markets, and in any case every prospective plan should consider this issue seriously.

Even within this negative overall evolution, it is evident that some players have managed to take advantage of the new environment to attain real improvements in their competitiveness. However, it is difficult to foresee that a few successful exporting activities may guaranty either the sustained growth required to lower unmet basic needs, or to regain the virtuous cycle of long-term investment and equitable growth. Especially taking into account that in the present context improvements in foreign competitiveness may be tied to both recessive pressures on domestic market supplying activities and productivity gains unprofitable for most national economic agents.

The announced economic reactivation in the second half of 1996 seems to be the combined effect of improvements in foreign funding conditions and ongoing growth in some industrial branches within the Mercosur. Empirical evidence is still insufficient to trust in a steady growing trend of relevant macroeconomic aggregates. The socio-economic scenario is then greatly conditioned both by the present situation of the Argentine economy and the international context, as will be presented later on in this report.

3 The energy context

The past and present situation of the Argentine energy system is analysed herein so as to explain the major factors that drive its dynamics, in the light of regulatory and institutional changes that impacted the energy industries in the last years.

As a context for mitigation policies both the structure of primary energy demand and the main strategies of energy companies shall be discussed in the following sections.

3.1 The Argentine energy system's present operation

The most graphic way of visualising the energy system's operation, regarding both the origin of supply of each energy source and its use, is through the flow chart presented in the following page. Such chart illustrates energy flows from production to end-use by various socio-economic sectors, where the width of the bars is proportional to the energy flow.

This flow chart represents in a simplified way the 1995 Energy Balance, as processed by the Energy Secretariat. As can be seen, oil and natural gas accounted for 86% of primary energy production, while biomass and coal are irrelevant, although some deficiencies in the energy information system to capture biomass production and consumption (fuelwood, agroindustrial wastes and charcoal) might overestimate the relative importance of fossil fuels.

Imports of primary energy sources are scarcely relevant at present, accounting for less than 4% of the country's domestic gross supply, and are mainly represented by natural gas imports from Bolivia, coking coal for the steel and iron industry and crude oil. On the other hand, the net exports of crude reached about 37% of the domestic production in 1995, tripling the sale of petroleum products abroad. The oil industry's total exports accounted for 24% of the total gross supply of energy in the country.

Until 1995 exports had not pushed up natural gas production, a situation that changed when 2 gas pipelines to Chile began to run in 1997. Natural gas production could increase even more if other projects for exporting natural gas to Chile, Uruguay and/or Brazil materialise.

Power plants act as a crossroad between various energy chains, as they use all the represented energy products as inputs and constitute the major intermediate use of the energy offered. As can be seen, Petroleum products currently burnt in power plants are quite low (7% of total inputs) versus natural gas (42%) and hydraulic energy (39%). The low natural gas price relative to petroleum products' prices is restraining the use of the latter solely to cases of gas supply shortages, either seasonal or permanent. Consequently, the future evolution of electricity generation should be analysed carefully in prospective studies of natural gas domestic market.

Imp. COAL Coke COKE

Losses + Self C.

Exp.

OIL Refinery OIL PRODUCTS Agro

Exp. Non Energ.

NUCLEAR Losses + Self Consum.

HIDRO Power Plants Transport

Electr.

Imp.

NATURAL GAS Gas Plants GAS Industry

Losses + Self Consum.

Venting. Charcoal Plant Buildings

BIOMASS

30
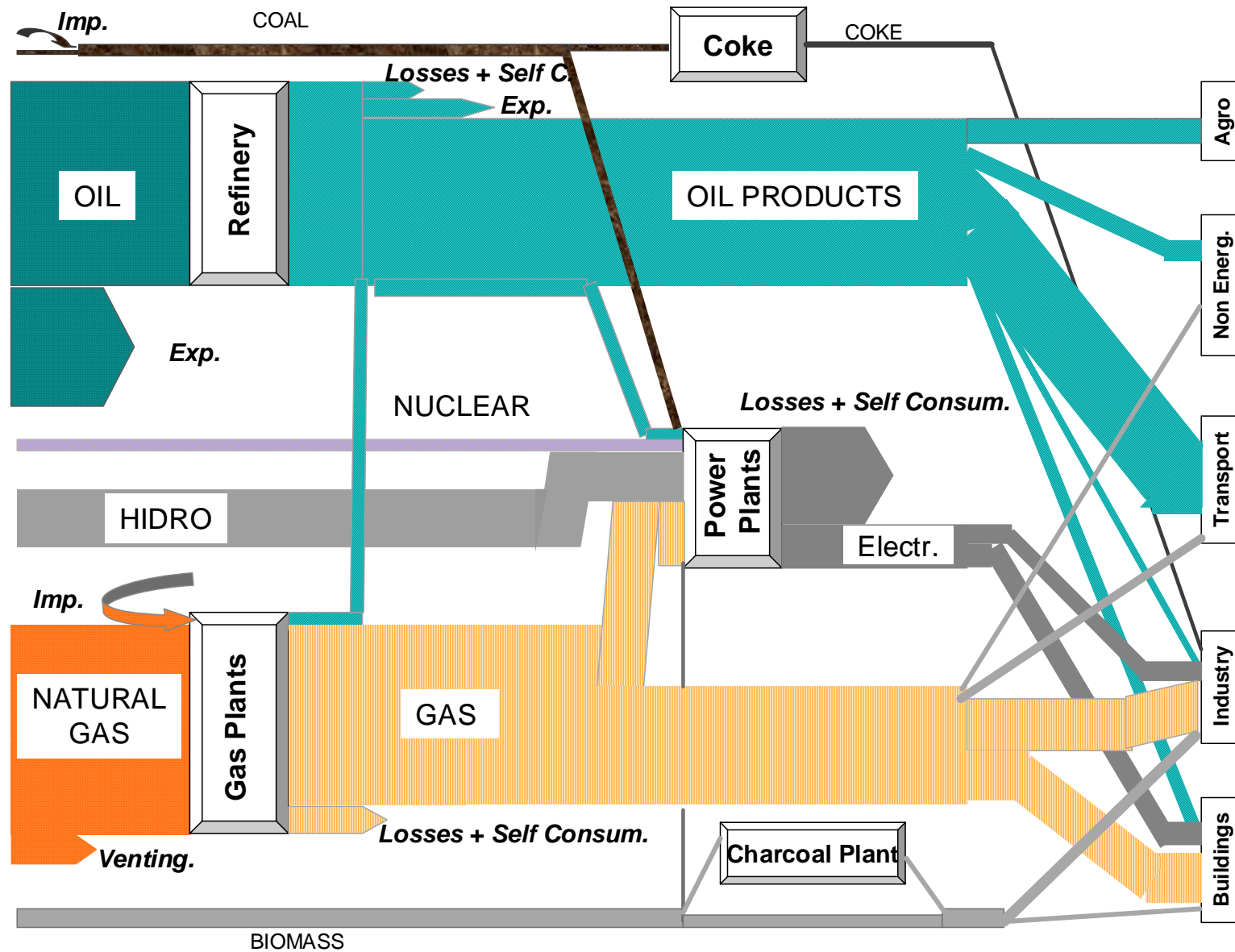
End-use energy consumption by the different socio-economic sectors presented a totally different situation. In this case, petroleum products supply 50% of the demand and natural gas one third. As noted, petroleum products are mainly used for transportation and agricultural machinery, while industries, 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 mechanisation of agriculture.

Only 50% of energy supply is devoted to end-use, 24% is exported and the remaining 26% is accounted for by losses (transformation, transportation and distribution) and the use by energy industries themselves (self-consumption).

Future expansion in natural gas production, either for domestic market supply or for export, could be restrained if the gas industry efficiency improved. In 1995, losses and self-consumption accounted for almost 21% of natural gas gross supply, i.e. 86% of the gas burnt by all power plants in the country. Almost a half of such losses were due to gas venting in gas fields, which represented 11% of natural gas domestic production and 161% of gas imports from Bolivia.

As can be noted, the size of the venting would permit to expand supply without necessarily increasing production. However, the effective improvement of the gas industry efficiency shall depend on production conditions and the effectiveness of regulations penalising the waste of gas.

3.2   Historic evolution of final energy consumption

The historic trend of final energy consumption shall be discussed in this section, i.e. removing from final consumption all non-energy products obtained from oil, as well as the energy products used for non-energy purposes.

3.2.1 The total final energy consumption

The frequent crises that affected the Argentine economy during the past thirty years have influenced the evolution of final energy consumption. Nevertheless, only in times of deep economic recession (1975, 1985 and 1989) has the unequivocally upward trend in energy consumption been interrupted.

In general GDP-elasticity of final energy consumption substantially grows in recessive periods. Although such results should be expected because of the asymmetry of consumption's response to changes in economic activity, the size and origin of such phenomenon vary depending on prevailing circumstances.

In Argentina, as from the mid-'60s, GDP-elasticity of energy consumption was about 0.8% in economic expansion periods (1965/70; 1970/75 and 1990/94). In the second half of the seventies, the higher incidence of energy-intensive industries in a context of economic stagnation, together with higher consumption in transport and buildings, drove elasticity to almost 1.4.

The deep economic recession during the first five years of the '80s decreased energy consumption in transportation and, to a lesser extent, in the industry. Larger consumption in residential and commercial sectors could not offset such decrease and a slight drop occurred in total final energy consumption. In spite of the drop in

consumption, GDP-elasticity in the 1980-1985 period was almost none evidencing certain downward inelasticity.

On the contrary, the second half of the decade evidences a slight recovery of energy consumption, in spite of the economic stagnation. The residential and commercial sectors were solely responsible for the increase in energy consumption, as the industry and transport did not substantially change their share. As a consequence of such situation, GDP-elasticity reached unusually high values, (3.9).

The highest growth rates of the whole period under analysis were recorded during the last five years. However, and as discussed in the socio-economic diagnosis, the recovery of the country's economic activity occurred mainly in the 1991-1994 period, as in 1995 the GDP dropped 4.4% compared to the previous year. Consequently the average value for the period combines clear economic reactivation and high recession, artificially increasing GDP-elasticity slightly above the unity.

If both effects were separated, GDP-elasticity would be slightly under 0.8 for the economic growth sub-period and -0.87 during the 1995 recession, thus reflecting an increase in energy consumption in spite of the drop in economic activity. Most of the 1995 energy consumption increase occurred in the industry, even when it was the most affected by the economic recession (almost 7% drop in value added in manufacture). Although no reliable statistics exist in the country regarding energy consumption by each industrial branch, the 1995 consumption should be expected to be driven by the food industry and basic metal production, which were the only manufacturing activities unaffected by the generalised recession.

Along the whole period, the most dynamic sectors regarding energy consumption were the residential and services sectors[10] reaching a share close to 32% in 1990, which decreased to 28% in 1995. It should be pointed out that such high share of the residential and services sector was achieved in spite of using highly-efficient commercial sources such as natural gas and electricity, which in 1995 represented altogether more than 83% of the sector's final energy consumption. Biomass fuels, on their part, accounted for less than 4% of the sector's energy consumption.

In fact, the high residential and services sector's share in energy consumption during the Eighties relied on both the industrial relapse and the standstill of energy consumption for transportation, as well as the lack of a policy to promote the rational use of energy (RUE).

Energy consumption for transportation, which reached almost 434.7 PJ at the beginning of the 1980s, dropped reaching in 1990 levels similar to those registered in 1978 (some 397.3 PJ). This situation reverted in the last five years when transport's consumption grew by 39%, thus turning such sector into the major driver of final energy consumption, broadly surpassing the residential sector's.

Regarding energy sources, the evolution of consumption clearly illustrates the impact of the energy policies implemented most of the time during the last decades, discussed in Section 3.3 below. The expansion of electricity and gas distribution networks, together with a promotional pricing policy for natural gas vis-à-vis petroleum products permitted the penetration of such sources in end-uses, as seen in Figure 1. To show structural changes in final energy consumption by source, the period under analysis

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[10] Sectoral consumption rose at an average annual rate of 2.9%, versus 2.3% of total final consumption.

has been extended in order to feature the historic penetration and substitution process of petroleum products.

Figure 1   Total final energy consumption by source
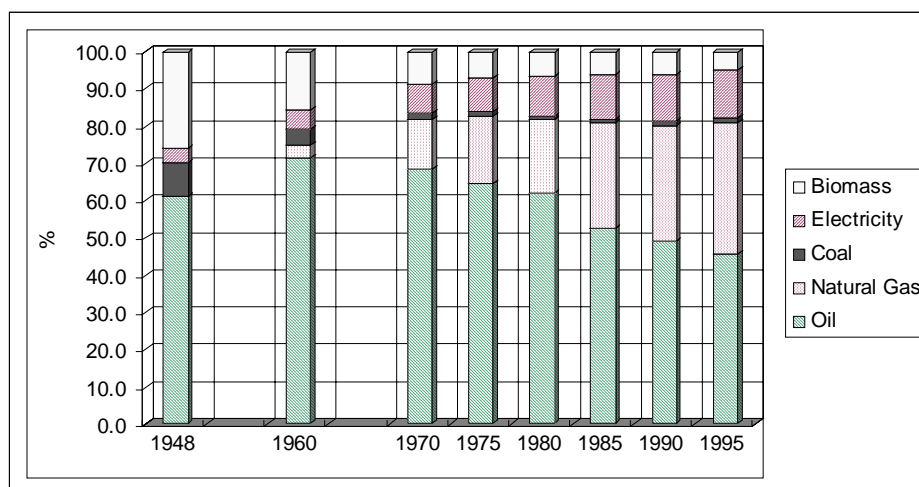
Natural gas availability at reasonable prices in a vast part of the country prevented electricity penetration in thermal uses, with the sole exception of certain industrial processes where electric furnaces improve production quality. This fact has limited the share of electricity in energy consumption, although its expansion has been steady during the whole period under analysis.

The substantial share of transport in total final consumption, based almost exclusively on petroleum products, keeps from seeing in Figure 1.the size of gas and electricity penetration in other consumption sectors. As will be seen later on, petroleum products only supplied 13% of the residential and commercial consumption and 6% of the energy requirements by the industry in 1995, which evidences a certain degree of saturation in natural gas penetration. To achieve a larger gas penetration replacing petroleum products would also call for both distributing network and truck-pipelines capacity expansion. Regarding gas supply during the peak demand season, priority has always been given to domestic, commercial and small industrial customers; while large industrial users have to switch to petroleum products during the winter if caps are placed on supply by insufficient gas pipelines' capacity.

3.2.2 Industrial consumption

Along the whole period under analysis the manufacturing industry suffered substantial structural changes which naturally reflected on the size and structure of energy consumption. Given the difficulties faced to obtain a consistent series of industrial activity levels from 1970 until to date, mentioned in the socio-economic diagnosis, we shall only discuss the evolution recorded since 1980.

As seen in Figure 2, industrial activity dropped during the '80s. The years 1985 and 1990 represent the lowest recessive peak. Although activity levels reflected on energy consumption, which in the course of the decade dropped by almost 5%, the industry's energy intensity exhibits an upward trend, especially in the first five years.

In general terms it could be said that the metal-mechanic industry was affected the most, losing near 10 share points in value added in manufacturing (VAM). Greater

stability in the production of non-durable goods strengthened their supremacy in the manufacturing industry, reaching almost 40% of the VAM in 1990.

Figure 2   Energy intensity
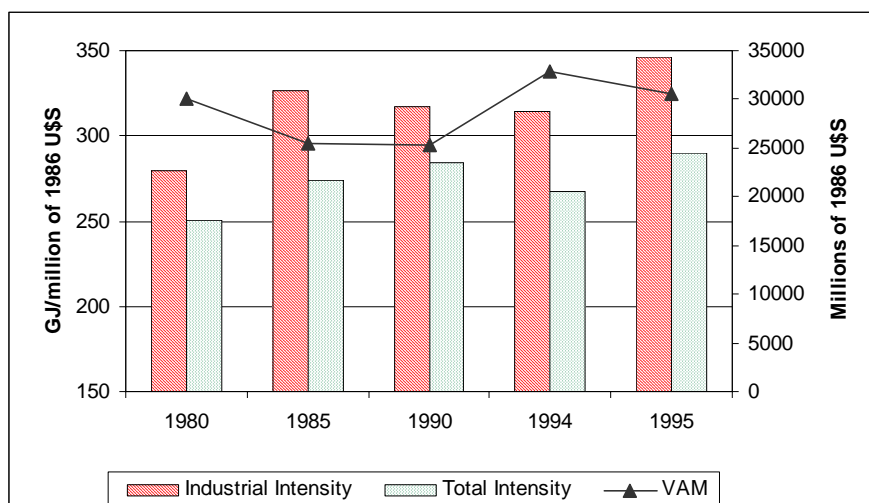
Within this context, certain more energy-intensive industries enjoyed subsidies and some protection against foreign competition[11], which contributed to increase the industry's energy intensity in this period. It is interesting to note that total energy intensity had also a strong upward trend between 1980 and 1985 (see Figure 2), driven in this case by energy consumption expansion from the residential and commercial sectors.

To analyse the last five-year period (1990-1995) it was decided to separate the industry's expansion stage (1991-1994), thus allowing to identify the effects of the strong recession that followed the financial crisis of the end of 1994 caused by the bottleneck of the Mexican foreign sector.

During the expansive stage, the industrial energy intensity remained stable due to the dynamic of paper and paste production, basic metal industries, and the automotive industry. Technological renovation in the food industry should also be considered, resulting from the transnationalization of domestic companies, together with substantial automation. However, during this period industry grew less than the tertiary sector of the economy, which results in a 6% decrease in total energy intensity.

During the 1995 recession the timber industry (-27%), the metal-mechanic industry (-17%), non-metallic mineral products (-11.5%) and the paper industry (-6.8%) were especially affected. On the other hand, food and basic metallic minerals' production have continued their upward trend. This fact, together with an increase in the idle capacity of other industrial branches accounts for the growth of the industry's energy intensity, also witnessed in the whole economy. In the latter case, the close to 9% growth of total energy intensity relies almost exclusively on the transport sector, as consumption in the remaining socio-economic sectors recorded no significant changes.

Such structural movements in both the manufacturing activity and the related energy intensity run together with equally important changes in the type of energy source

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[11]   Especially the steel and iron, cement, automotive and sugar industries.

used by the industry. To give a clearer historical perspective of the substitution process between energy sources in the industry, Figure 3 illustrates the evolution of various energy sources' share in final industrial consumption along the last 50 years.

Figure 3   Industrial energy consumption by source
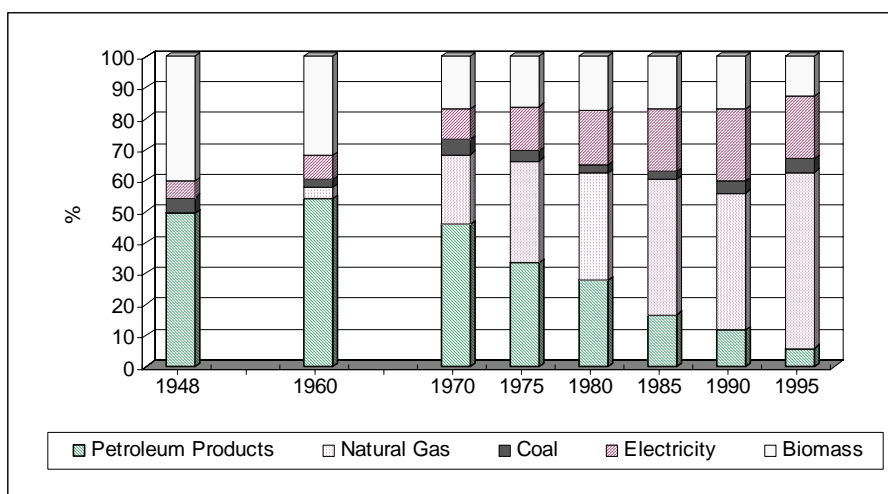
As noted, natural gas presently plays a major role in supplying thermal consumption, which at the beginning of the '60s was mainly supplied by petroleum products and biomass fuels. Even biomass fuels have surpassed petroleum products, mainly due to the use of agroindustrial wastes especially in the sugar industry.

Natural gas penetration is strongly dependent on gas transportation and distribution availability. Although a certain expansion of such services has been witnessed in the last years, no significant differences appeared in the areas supplied, even though restrictions on winter supply decreased thanks to the expansion of main gas pipelines capacity. Therefore, the greater gas penetration in the industry during the last decade seems to reflect mostly the industry concentration process around large urban centres supplied by this service.

The incorporation of new technologies for certain energy uses, particularly the use of heat pumps burning gas for air conditioning and food preservation, could rush gas penetration in this sector. Such greater use of natural gas would negatively affect the present share of electricity.

Structural changes in production, as well as technological renewal, also favoured greater penetration of grid electricity, especially during the 1980s when it supplied over 23% of the industrial total energy consumption. The steel and iron industry, with the incorporation of electric furnaces, was not alien to such electricity consumption expansion.

Additionally, electricity tariffs historically favoured growing electrification. Even now prices are relatively low, although substantial tariff dispersion exists between large users and small industries, favouring the former regarding both gas and electricity.

3.2.3 Energy consumption for transportation

Energy consumption for transportation, which suffered a squeeze during the '80s, grew steadily during the last 5 years (close to 7% per annum).

As illustrated in Figure 4 the drop in consumption in the 1980-1985 period affected passenger transportation the most, which decreased its share in energy consumption to less than 40% in 1985. In the last ten years, however, passenger transportation has shown a greater drive than cargo transportation, whose share in energy consumption decreased 4 points between 1985 and 1994.

Figure 4   Energy consumption for transportation
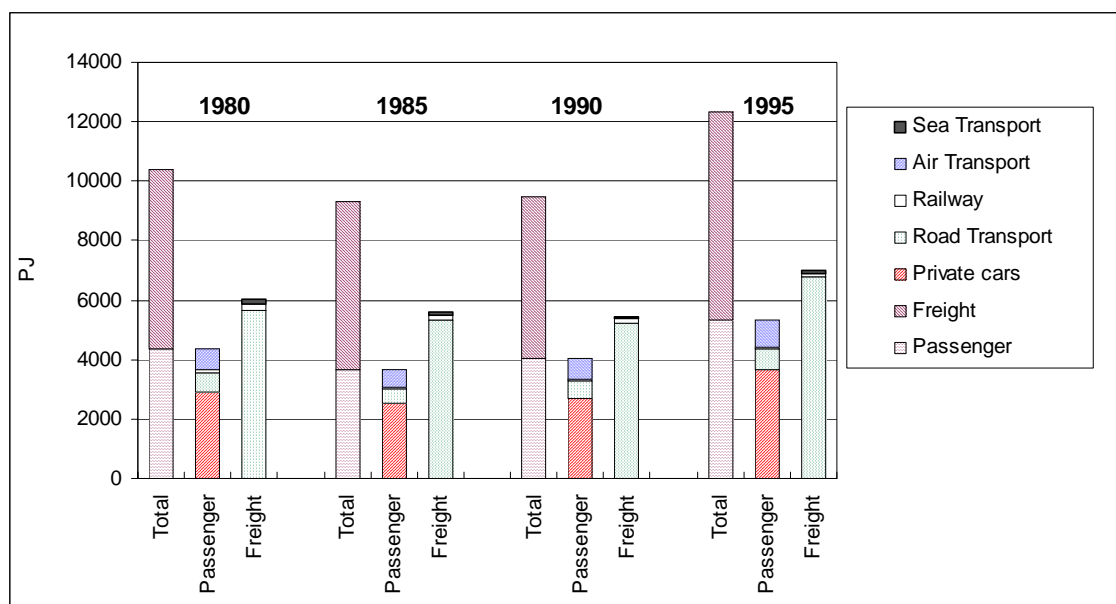
As for passenger transportation, automobiles (private cars and taxis) have a strong impact on energy consumption (above 68%), whereas public transportation has been losing share, especially lately. This phenomenon affects both buses and railways, as well as underground.

In the case of railways, the progressive deterioration of the service and the subsequent elimination of a major part of long distance services, before the privatisation, meant a 54% reduction in passenger-kilometre transported in the last ten years. Given the conditions under which the privatisation materialised it is unlikely such situation will reverse in the future, except in metropolitan short and intermediate range services.

In the same period, energy consumption from passenger trains only decreased by 27%, impairing its energy efficiency in terms of consumption per passenger-kilometre. This shows that changes in the transport policy affected more the occupancy level than the annual distance travelled, although the increase in specific consumption may be due also to the obsolescence of both the rolling stock and railway infrastructure in general.

Buses captured some of the transportation demand lost by the railway. However, such phenomenon seems to have occurred only along the last five years, as all indicators show a stagnation of public transport between 1985 and 1990.

In the last years distances covered by the units, both in short, medium and long distances, grew about 45%. This expansion however was not reflected in fuel consumption, which only grew 15%, thanks to the renovation of the fleet and the incorporation of more energy-efficient units.

The last five-year period also evidences a remarkable increase in domestic airway transportation demand (close to 25%) after the squeeze suffered at the end of the '80s because of the economic crisis. Lower air fares, the economic upswing and the elimination of certain long-distance railway services, contributed to increase the domestic airway transport's performance.

This specific consumption of domestic flights, in terms of fuel per passenger-kilometre, decreased 14% between 1990 and 1994 thanks to planes' highest occupancy ratio and the renovation of part of the fleet. In spite of this energy efficiency improvement in domestic air transportation, fuel consumption grew close to 40% almost exclusively from more international flights.

As regards passenger transportation, automobiles account for most of the energy consumption. In 1994, Argentina reached a motorization rate of 7.6 inhabitants per vehicle, considering both private cars and taxis and "remises" (hired car with driver). Although the motorization rate has grown steadily throughout the period under analysis, the fleet expanded mainly at both the beginning of the '80s, when it reached 9.9 inhabitants/vehicle, and in the last four years.

The fleet expansion drove the automotive industry growth, which reached an average 43% per annum between 1991 and 1994, i.e. tripling the domestic automobile production in the same period.

In spite of new cars, the fleet is still quite old. Suffice it to say that only 27% of the cars are less than 5 years old, while 59% exceed 10 years and 34%, 20 years. A stricter control in the technical status of vehicles, implemented in 1996, will probably reduce the fleet and the motorization rate, lowering the average energy consumption.

Freight transportation has only recovered in the last years after a decade of stagnation (See Figure 4). Such recovery led to 6.4% average annual growth in energy consumption between 1990 and 1994.

Road freight transportation has increased throughout the period, to the detriment of railways, river and ocean freight. Actually the Tons per kilometre (Ton-km) of goods transported by railway have decreased by 33% in the last ten years. In the last 5 years the loss of railway freight seems to have slowed down, in spite of a 14% drop.

Comparing such values to energy consumption by railways, it appears that energy intensity, in terms of energy used per transported Ton-km, slightly decreases (5%) in the last five years, although it exceeds by 20% the 1985 values. Perhaps in the future private companies now managing freight services will partly recover the share lost by railways in goods' transportation and improve energy efficiency.

As for road transportation, the values in Figure 4 include both urban movements of goods and interurban transport on heavy-duty trucks. Large trucks have increased their share in energy consumption from freight road transportation, from 52% in 1980 to close to 59% in 1994. However, the large truck fleet evidences a downward trend through the replacement of gasoline-fuelled trucks.

In general the freight transport fleet exhibits signs of ageing even more than cars. Only 23% of the total vehicles (approximately 1,150,000 in 1994) is less than 5 years old, while 66% is over 10 and 29% over 20 years. The obsolescence of the short and intermediate range vehicle fleet strongly impacts the above mentioned figures.

As for energy sources used by the transport sector, throughout the period under analysis a substitution of gasoline occurred, decreasing their share by 13%. Such substitution was mainly led by freight transportation, although it was also replaced in passenger transportation. The evolution of automotive fleet structure for freight transportation per type of vehicle and fuel clearly shows that the greatest transformation took place in the medium range transportation (between 2 and 4 ton cargo capacity) and with greater intensity in the first half of the '80s. In short distance transportation (below 2 ton), on the other hand, petrol fuelled vehicles still account for 70% of the existing units. For long distance transportation, 6% of the fleet is still petrol fuelled, although same account for less than 4% of petrol consumption by freight transportation.

In the case of passenger transportation, petrol is only used by cars (private, taxis and "remises") as all buses had diesel engines along the whole period under analysis. The automobile fleet evolution shows a 10-point reduction in the share of vehicles with petrol-fuelled engines, which in 1994 still accounted for 89% of the total.

It should be noted that petrol sales were also affected in the second half of the '80s by the drop in real salary and the economic crisis, a situation which reversed, regarding petrol sales, as of 1991.

Low relative prices of gas oil contributed to the replacement of petrol, rapidly offsetting the higher investment costs incurred by users. Almost 5% of the 1994 car fleet corresponded to diesel engine vehicles, a penetration achieved almost exclusively since 1985. Nevertheless, the share of gas oil in energy consumption from passenger transportation decreased in the last 5 years due to both the lower growth of public transportation and the strong growth of private cars.

An element that restrained the penetration of gas-oil fuelled cars, in spite of gas oil much lower price relative to petrol, was the promotion of compressed natural gas (CNG) through an adequate pricing policy. This fuel permits existing vehicles with Otto engines to be adapted at a relatively low cost.

Between 1985 and 1994 over 6% of the car fleet was adapted for CNG, i.e. about 300,000 taxis and private cars, responsible for over 9% of the passenger transportation fuel consumption. Such figures were obtained even when CNG is not used by the public transport. Gas oil's low price and a fleet equipped with diesel engines discouraged vehicle adaptation, in spite of technical solutions that might render viable buses' conversion.

CNG did penetrate the freight transportation, accounting for about 4% of this subsector's total fuel consumption. This results from the adaptation of about 5% under 2-ton local freight vehicles.

The future role of CNG in the transport sector will strongly depend on its relative price compared to petrol and gas-oil. As later discussed, the institutional reform of Argentina's energy sector may introduce substantial changes in the past pricing policy.

3.2.4 Residential, commercial, and services' energy consumption

Families and stores' energy consumption steadily grew in the last 35 years, and was less affected by economic swings than total final energy consumption in the country. Recessive periods (1975-1990) only tempered its energy consumption growth. During economic expansion (1970-1975 and 1990-1995) the trend of energy consumption seems to be tied to real salary evolution rather than to the per capita GDP.

These results are showing both the impact of the Argentine economy's growing outsourcing, especially as of 1975 and some downward inelasticity of energy consumption; as well as the influence of some energy sources' availability on energy consumption patterns in this sector.

Regarding the impact of supply on energy consumption, two sources have played a major role: electricity and natural gas. As seen in Figure 5, both sources presently account for over 80% of the sector's energy consumption, with a clear pre-eminence of gas (60% of energy consumption) that shows a strongly expansive trend during the last 35 years. Such expansion occurred at the expense of petroleum products' substitution, as according to national energy statistics biomass fuels are negligible, although real consumption may be higher than the one recorded.

Figure 5   Energy consumption in the residential and services sectors
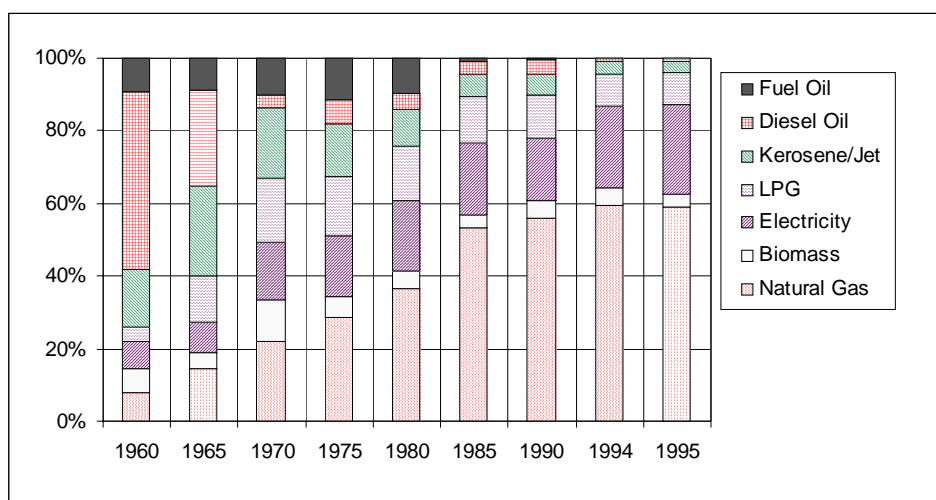
Considering the difference in performance between natural gas, liquefied petroleum gas (LPG) and kerosene, as well as their relative prices in Argentina, it is clear that kerosene is an inferior-goods in the economic sense, and is therefore replaced by LPG in spite of its higher price. However, both of them are rapidly being substituted for natural gas whenever it is available.

Historically, price differences between natural gas and other fuels sufficed to rapidly offset the additional investments required for its use (pipelines and in-house installations). However, proper financing conditions were necessary to ease natural gas penetration and funds availability will be key to maintain petroleum-products' substitution in the future.

Presently natural gas covers not only basic cooking needs but also space and water heating. Besides its penetration in various thermal uses, natural gas' high share in total consumption also reflects the higher consumption induced by its availability. Surveys carried out in the country for various studies have shown the greater energy consumption for thermal purposes in families supplied with natural gas, within the same socio-economic level and under equal weather conditions. Thus, consumption "induced" by natural gas thanks to its ease of use and lower price per calorie has been confirmed.

A greater natural gas penetration in homes and commercial activities would call for distribution network expansion in the areas supplied[12]. Natural gas availability in the northeastern region of the country, not served yet, could promote the substitution of electricity in thermal uses.

As for electricity, up to the moment no true competition with natural gas has existed in the residential sector. In areas where both sources are available, a certain specialisation has been established: natural gas for thermal purposes and electricity for lighting, air conditioning (cold) and household appliances. However, greater competition may arise in the future between distributing companies to capture the cold air conditioning market in certain niches of the services sector.

Regarding families, in the last years a better metering of electricity consumption allowed to quantify the real sectoral demand. Although the new metering affected the electricity bill for a wide range of customers, their reaction depended greatly on their income level. While low-income customers reduced their consumption to strictly basic levels, middle-income customers expanded their stock of electrical appliances and increased their electricity consumption.

This effort to assimilate billing records to real electricity consumption resulted in lower distribution losses, which proved to be mostly caused by illegal consumption rather than by the poor condition of electricity distribution grids.

3.3 Energy policies and energy supply transformation

Beyond the influence of the economy on final energy consumption, it is clear that energy policies contributed to alter the structure of energy consumption and supply throughout the country. However, the role of the State in defining the energy supply structure, as well as the instruments for policies' implementation have completely changed since the reorganisation and privatisation of the energy industries in 1992. The following sections analyse both periods separately.

3.3.1 Energy policies and their effects until 1992

In spite of having a diversified amount of resources, energy supply at the turn of the century depended on imported hydrocarbons by 60%, while 39% corresponded to biomass fuels. The gradual substitution of biomass fuels, as from the 1950s, intensified dependency on hydrocarbons even more, notably that of oil, which, by substituting coal, supplied 76% of the apparent energy consumption in 1955.

Notwithstanding the early discovery of oil fields in the country, several factors prevented local production of crude oil and petroleum products from playing a more active role in the country's energy supply. During the first half of this century, subordination of energy issues to the country's economic policy and its strategy for insertion into international markets favoured the imports of energy products (initially coal and later crude oil and petroleum products).

The application of an energy self-supply policy only took place by the end of the Second World War, when risks posed by foreign dependency to the success of industrialisation programs became quite evident. To achieve energy self-supply, the guidelines of the energy policy devised by the mid 1940s were as follows:

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[12] It is considered that around 30% of the population in areas supplied by pipelines lacks the home connection.

- to expand energy supply, so as to allow for further economic growth and improve the people's standard of living throughout the country;

- to increase local production of all energy sources (electricity, natural gas and petroleum products[13]), diverting funds to the development of basic infrastructure;

- to diversify primary sources used in the country, better adapting consumption structure to that of reserves, particularly promoting the use of natural gas and hydropower;

- to encourage a wider knowledge on local energy resources, through the analysis of the hydroelectricity resource and the promotion of hydrocarbon mineral surveys.

Although environmental issues did not represent the main concern in planning energy strategies by the State, changes produced throughout these last fifty years reduced environmental impacts from energy consumption and supply in the country.

Political instability worked against the continuity of energy self-supply strategy, only achieved the last decade, after forty years of having been set as a national goal. It goes beyond the scope of the present analysis to delve into the fluctuations experienced by energy policies, as well as into the causes that originated them. However, it seems relevant to enumerate the transformations experienced by the energy system within the framework of this constantly declared (although not always instrumented) aim of reaching energy self-supply.

The evolution of apparent energy consumption by source during the last fifty years clearly shows the success reached in reducing dependency on petroleum products through a more intensive use of natural gas, hydroelectricity and uranium, in spite of the significant substitution of biomass fuels (See Figure 6).

The biggest efforts to achieve such modifications were made in energy supply, although a higher availability of more efficient sources and the pricing policy also contributed to alter the structure of final energy consumption. Such changes made the apparent consumption by source fit better the structure of domestic reserves, as can be seen when comparing Figure 6 and Figure 7.

Efforts made in both knowing better the hydropower resource and hydrocarbon exploration allowed a substantial increase in energy reserves until 1980. The slight reduction in reserves registered in 1990 reflects an international audit carried out immediately prior to the privatisation of the State-owned oil-company, which reduced the economic appraisal of assets to be privatised. Actually, after privatisation, hydrocarbons' reserves returned to levels similar to those originally estimated by the public oil-company.

Hydropower kept its relative significance in energy reserves throughout the whole period[14]. Conversely, the structure of hydrocarbon reserves was substantially altered as

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[13] There are coalfields in the southern region of Argentina the working of which was almost solely directed to fuel power stations, since end users opted for more efficient and easier to handle fuels. The promotion of a more intensive use of domestic coal in power stations was brought forward at the beginning of the 1970s. However, coal production never reached economically competitive levels, and the coal-fuelled plants ended up burning fuel oil and natural gas.

from 1978, when large natural-gas fields were discovered in the Comahue region. Such findings strengthened policies to substitute petroleum products, both in power stations and in final consumption. This allowed natural gas to reach in 1995 a 44%-share in the apparent energy consumption (See Figure 6), one of the highest at international level, only surpassed by the Netherlands and Russia.

Figure 6   Apparent energy consumption by source
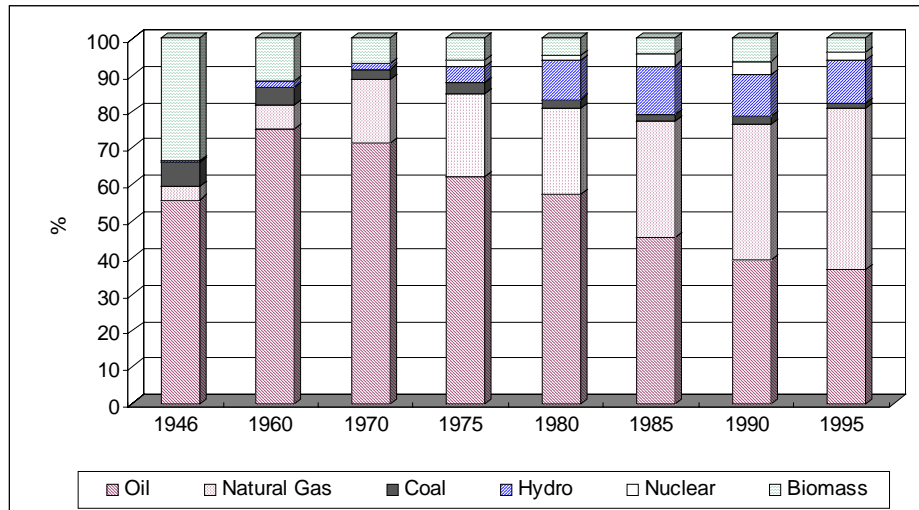
Figure 7   Energy reserves
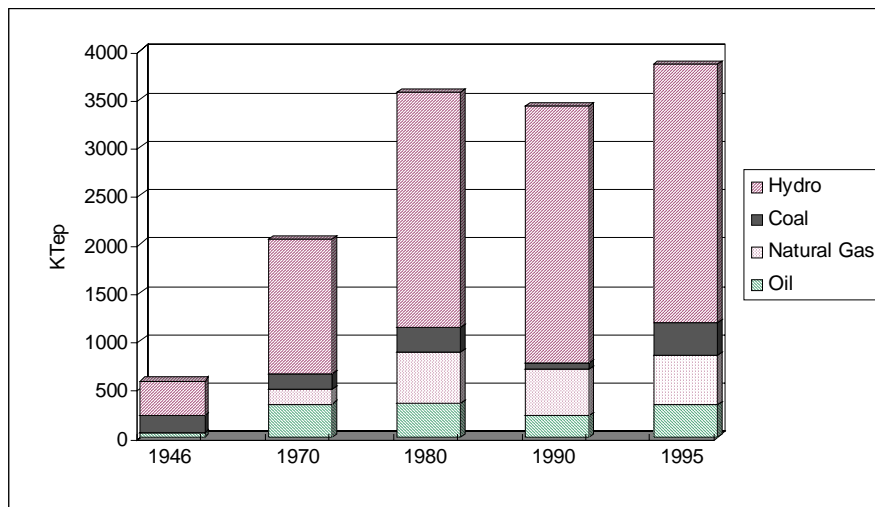
As regards power stations, the decision made during the 1960s of building large hydroelectric projects and developing nuclear technology changed the generating structure as from 1975, when the mentioned works started operating.

Continuity in electricity policy allowed for a gradual reduction in the share of conventional thermal stations, which produced 90% of the electricity supply until 1970. Hydropower and nuclear electricity reached their peak share in 1985 (64%), although

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[14]   Hydroelectric reserves in Figure 7 are equivalent to the fuel consumption in thermal plants for generating the hydro potential during a fifty-year period, considered as the average lifetime of hydropower plants.

delays in the construction of new stations of this type brought down their contribution below 56% of total power generation in 1995.

Conventional thermal stations, on their part, acted as a "counter seasonal" demand, improving the utilisation factor for trunk gas pipelines. However, the intensive though interruptible use of natural gas in power stations was promoted only after the discovery of large natural-gas fields by the end of the 1970s. The massive adaptation of existing thermal stations to burn natural gas resulted in a rise —from 38 to 84%— of this source's share in total fossil fuels burnt in power stations between 1980 and 1995. Such achievement was favoured by a relative stagnation in conventional thermal generation.

The production of associated natural gas grew even more rapidly than consumption during the '70s, driven by oil production. This resulted in increased vented gas, which reached 32% of the total natural gas production in 1978. During the '80s, pipeline capacity expansion and gas fields' working decreased vented gas to 11% of the production.

The rise in natural gas venting by the end of the '70s was also related to the privatisation of some oil fields under no specific regulation about venting, which were passed only at the beginning of the '80s. More recently, wholesale electricity market conditions promoted the use of vented gas for electricity generation, which allowed to keep venting around 11% of gas production within a highly expansive environment for oil production. A drastically decrease in gas venting is expected in the next years as a result of the new much more restrictive regulations on gas venting.

3.3.2 Policy tools used in the past

To achieve this deep transformation of the energy sector, the State actively intervened within three spheres:

- formulation of policies and strategies to change the structure of domestic energy-resource use, including legal and regulatory aspects;
- development of the necessary physical infrastructure to achieve such transformation;
- controlling the provision of energy services.

In the past, legal and regulatory instruments reasserted the State dominion over energy resources and emphasised the role of public companies in the provision of public services. Nonetheless, and quite particularly within the oil sector, these instruments were declaratory rather than effective. Only in the last years after the reforming, legislation substantially altered the role assigned to the State in the handling of energy matters.

During the former forty-five years, the State resorted to energy planning as a proper instrument to formulate energy policies and co-ordinate them with social and macroeconomic goals. State-owned energy companies were in charge of implementing such policies. These companies made use of energy plans to formulate their works programs. Beyond co-ordination problems within the energy sector itself and financial difficulties registered during those forty-five years, efforts made were relatively successful in promoting the transformation of the energy sector.

The government implemented a fluctuating pricing policy, which were not always set exclusively on the basis of energy strategies. Relative retail energy prices responded in

general to the intention of promoting substitution between sources, especially between natural gas and petroleum products. In the special case of electricity, however, the decentralisation of distribution services carried out during the 1980s led to a dispersion in electricity rates of questionable regional equity, in many cases hindering a higher penetration of this source.

However, during the1975-1990 period average prices and retail rates were more related to the anti-inflation plans implemented by the government than to energy strategies. This rate lag, within a context of high inflation, faced energy companies with financial difficulties, which ended up deteriorating their technical and commercial performance, especially in the case of electricity companies.

Pricing in the energy-chains' intermediate markets was the result of a struggle between private and public economic agents to capture the energy rent. Obviously, far from "mediating" in this struggle, the State became the privileged stage on which political, social and economic disputes were settled. Although such pricing "system" was used repeatedly in all energy chains, it was probably within the oil sector where it had greater influence on public companies performance and on the possibilities of achieving energy-policy goals.

Historically the Argentine State weakly exercised its regulatory duties within the energy field. Until the mid 1940s, government agencies in charge of regulating and controlling foreign companies and concession-holders showed great difficulty in enforcing legal duties and the terms of the concession contracts previously granted, although it is also true that government attention was not focused on energy problems. In the special case of the electricity service, lack of control over foreign concessionaires brought serious difficulties as regards supply, as well as abusive rates and low quality of service.

Partly due to the recognition of these difficulties, and partly agreeing the ruling notion in those times on the active role the States should play in constructing basic infrastructure for economic development, the Argentine State engaged more actively in energy production and service provision as from 1945. This engagement meant the strengthening or setting up of public companies for oil, natural gas, coal and power supply. These companies constituted the tool to put energy policies into practice, bringing about the system transformation already depicted. Nevertheless, such transformation was only possible through a substantial expansion of energy infrastructure.

Within the power sector, for example, achieving higher electricity penetration and changing the energy-sources used by the sector represented the following:

- expanding installed generating capacity 12.5 fold, which is the equivalent to an annual growth rate of nearly 6% during forty five years;
- establishing regional interconnected systems which allowed to centralise electricity supply, for which close to 27000 km of sub-transmission lines were built;
- creating a national interconnection network, which integrates 92% of the country's electricity generation and demand throughout 7100 km of 500 kV lines.

The efforts made by the natural-gas public company to carry the fluid from fields to consumers represented the construction of almost 22000 km of trunk and secondary

gas pipelines, 1500 km of harnessing lines in gas fields and 51000 km of distribution lines.

The role played by the State-owned oil-company in each activity stage could be summarised by the following data:

- it contributed with 94% of the total proven reserves incorporated during his last thirty-two years as a public company, for which it drilled almost 3300 exploration wells (95% of the total wells drilled during such period);

- it increased crude-oil production at an average annual rate of 4.2% during the last thirty-two years, even when some contracts signed by the government with private companies reduced the State company's share in crude-oil production from 88 to 65% during the same period;

- it built six refineries, with an installed capacity of 71000 m³/day, equivalent to 62% of the country's capacity.

During the last years, it has been pointed out that the State's regulatory and service-rendering-control duties have been clouded or set aside by its role as producer, through public companies.

In fact, regulation has registered serious deficiencies, but not exactly due to lack of control. On the contrary, such deficiencies were the result of overlapped controls and the use of public companies as means to transfer rent to private agents, especially within the oil sector. The financial squeeze experienced by certain public companies as a result of this type of handling, and the decay of the quality of service in electricity supply represented the grounds used before public opinion to promote the recent energy sector's restructuring.

3.3.3 Regulatory and institutional reforming as from 1992

As a part of the State reforming launched in 1990, a substantial change took place in the institutional arrangement and regulation for all energy activities, having different characteristics according to the energy chain in question.

The reasons given to promote such restructuring, and which to a large extent determined its characteristics, were mainly the following two: the State's financial incapability to develop production activities and its "inefficiency" in carrying out this type of activities. On such grounds, the private sector was proposed to be responsible for running the existing facilities and also to invest in future expansion, while the State would intervene as little as possible so as not to hinder private initiative but should promote competition and control monopolistic activities.

The participation of private agents in the oil sector dates from long time ago due to fluctuating government policies in this field even when the oil-company was the oldest public energy-company in the country. The need to resort to private companies to achieve oil self-supply was repeatedly brought forward. It has already been shown that exploration efforts and success attained in increasing the nation's proven oil reserves have to be attributed to the State company, even when certain exploration contracts were executed with private companies on many occasions.

Production contracts did not represent economic benefits either for the State company or for the country, since the prices paid for crude oil obtained by private companies, were far higher than the production costs of the State company and, in many cases, also higher than international prices. Whenever domestic oil production increased the

contribution of the State company was always more significant than that of private agents, who used their production volumes as a tool to exercise pressure to renegotiate the prices of their contracts.

Once self-supply was reached at the beginning of the 1980s, promotion of private participation was carried out to encourage oil exports. Although some prior attempts had been made, the true restructuring of the oil sector, known as "deregulation of the oil sector," took place as from 1990.

Changes in oil regulation included the following items:

- the cancellation of all the concessions on exploration areas already in the hands of the State company, advancing the possibility of granting it to private companies;
- free availability of crude oil for private companies, which were authorised to freely export and import crude oil and petroleum products;
- free availability in foreign currency of the profit obtained by companies from the sale of free-available crude oil and petroleum products;
- domestic prices in line with international ones;
- free purchase of crude oil for refineries, until that time regulated by the Energy Secretariat through the setting of quotas;
- third parties access to pipes and other means of transportation belonging to the State oil company;
- possibility of installing new refineries and retail gas stations.

Regarding the institutional arrangement, already-existing production contracts were turned into concessions or associations with the State oil-company before its privatisation. The re-conversion of existing contracts, aimed at meeting the oil demand of private refineries with private supply, assumed different forms depending on their selling prices. Whenever the prevailing selling price was higher than the international oil price (secondary production areas), a new concession was granted to the former contractor. On the contrary, when the selling price was below the international one (main production areas), the possibility to associate with the State oil-company was offered to contractors

The State oil-company's restructuring and privatisation was carried out in different stages, namely:

- privatisation of secondary production areas, some of them with high natural-gas potential, an output higher than 200 m^3/day and low operation costs;
- privatisation of main production areas, through the sale of rights of association with the State company, with rights over production and reserves. Association percentages ranged between 60 and 90%, according to the area. Natural-gas reserves in privatised areas were transferred to the private sector together with oil reserves;
- privatisation of "non-essential" assets of the State company, which initially included three refineries, one oil pipe, part of its fleet of ships and drilling and seismic-record-gathering equipment.
- following the Hydrocarbon Federalisation Act's prescriptions the State company's capital stock was distributed as follows: 51% for the Federal State, 39% for those provinces that converted unpaid oil or natural-gas royalties into

oil-company's shares, and up to 10% for the company's workers. The Act also imposed the privatisation of at least the 50% of federal and provincial shares, but a new act should be passed to reduce the federal share below 20%. During 1993 the National State transferred 59% of the company stock to the private sector.

The reforming in the natural-gas sector mainly affected transportation and distribution activities, since its production was always integrated to the oil chain. The oil company privatisation only reinforced this situation as natural gas reserves were transferred to oil companies. Regulations for the natural gas and the electricity industries are quite similar. For that reason, the basic features of the regulatory frameworks in force will be presented jointly, pointing out differences whenever appropriate.

The new scheme, inspired to a large extent by the restructuring of the British electricity sector, is aimed at achieving higher efficiency in supplying the service by promoting as much competition as possible among the parties. Institutionally, it aimed at attaining maximum horizontal and vertical partitioning of the companies so as to facilitate competition, separating the different activities related to supply. As regards ownership, the intention of the authorities was the State withdrawal from the electricity and natural gas industry, transferring its assets to private investors.

The aims of these changes are the following: to protect consumers' rights; promote market competitiveness; encourage private investment to guarantee long-term supply; foster a reliable operation and free access to services; and regulate transmission activities and distribution at reasonable rates.

Distribution and transmission, due to their monopolistic attributes, are regulated activities and additionally require the granting of concessions. Nonetheless, the expansion of the transmission network will be submitted to market forces.

Generators, on their part, must be granted concessions only to operate hydropower stations, while the installation of thermal stations needs authorisation to enter the grid and its regulation only involves aspects related to public security and environmental protection.

The agents taking part in one stage of the electricity chain cannot participate in another stage. Transmission independence is aimed at ensuring third parties' free access to the network. Distributors have also to guarantee third parties access, as long as they have available capacity in their distribution grid.

Competition must take place in the electricity-generation and natural gas production stages, materialised through a wholesale market (WM) which includes producers, distributors, brokers and large consumers[15]. In theory, State intervention in this market should be as reduced as possible, and prices should result from market forces.

As a consequence of this institutional arrangement, all electricity and natural gas supplied by the public sector is channelled through the wholesale market, which is divided in two segments, namely: a contract and a spot market. Distributors and large consumers may enter into supply agreements with producers and brokers, at prices freely settled in the respective contracts.

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[15] Gas producers, processors and storers are also included for the case of the natural-gas market.

The wholesale electricity market is managed by the Wholesale Electricity Market Managing Company (CAMMESA) which plans the operation of the interconnected system for six-month seasonal periods, so as to meet the expected demand with a reserve agreed between the parties (economic load dispatching).

The hourly marginal price defines the generators' selling price in the spot market and its seasonal average represents the basis to determining the purchasing price for distributors is the spot market. Distributors pay a differential price depending on their location in the system, which reflects their contribution to transmission losses. Distributors and generators also pay a fixed charge for connection and transmission capacity, and take part in reactive-power transactions.

On-line operation is carried out independently from contracts signed by generators, being it understood that any difference between contracted volumes and real operation will be channelled through the spot market.

Since the purchasing and selling prices in the spot market are different, a stabilisation fund was established, administered by the Energy Secretariat, to deal with financial gaps.

The retail market is also divided in a regulated segment and another open to competition among suppliers, which includes large consumers. The regulated segment guarantees monopoly to the distributor who is granted the concession, who has the obligation to supply any required demand under the terms of the concession contract[16].

Concession contracts should specify the obligations of the concession holders regarding technical and commercial quality of the service. The distributors' obligation to supply electricity is independent of power availability in the wholesale market, and the State has no commitment to cover eventual production deficits that could arise in the future.

The apparent contradiction between the distributor's obligation to supply on any condition in the wholesale market and the prohibition to act as a generator would seem to be aimed at formally maintaining both activities independent, forcing distributors to establish new companies which may offer power in the wholesale market.

In spite of these mechanisms to ensure the atomisation of the electricity industry and favour competition in the wholesale market, private suppliers are evidencing a growing interest to participate in more than one of said activities. This behaviour on the part of private investors, as shall be further explained, could be foreseen and is essential to reduce companies' exposure.

It should be pointed out that price setting in the spot market does not ensure marginal units to cover total costs, particularly in presence of over-capacity. Therefore, marginal plants considered as independent business units may be economically unfeasible, in spite of their importance for the continuity of the electricity service, unless they manage to guarantee a permanent income through contracts.

On the other hand, the large share of hydroelectricity, together with the plants' design, call for backup facilities with an uncertain operation that depend on hydrologic conditions. This feature of the Argentine power facilities increases price instability in

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[16]   Within the gas chain, supply responsibility also falls on transmitters, and should a supply request imply carrying out unforeseen works, concession holders are exempted from their obligation to meet said supply.

the spot market as well as marginal plant operators' exposure, who are unable to financially face a succession of wet years. Recent changes in regulation address this issue to lower hydraulic risk to thermal generators. The initially foreseen mechanisms to counteract these risks are:

- dismantling reserve plants —most of them are old gas turbines scattered along the various power regions—. This solution would result in decreased quality of service in different regions, given the instability of hydroelectric supply and the evident incapability to adjust the transmission system to new generation sites.

- entering into long-term supply contracts at prices allowing to cover their total costs. Initially provincial distributors have resorted to this mechanism to ensure their future supply, but uncertainty still exists regarding "reasonable" prices to secure supply. In general, both public and private operators seem increasingly concerned about the risk of contracting at higher prices than the spot market values. Provincial public companies are politically vulnerable and private distributors fear economic risks because should the contracted price exceed the spot market's price the difference would have to be absorbed by them.

- merging marginal plants with other processes in the electricity industry, e.g. more profitable generating units or electricity distribution. Private suppliers enjoying greater economic standing have been able to choose this option during the privatisation process.

Regulated retail rates should cover all distribution costs (expansion costs, network-operation and maintenance costs, marketing costs and electricity purchasing price in the wholesale market), including profits set by the regulatory body. However, not all concession contracts comply with such legal rules, as neither costs nor the enterprise's profitability are controlled.

General supervision and regulation of the electricity and gas industries is in the hands of national regulatory bodies, set up by statute as independent agencies within the scope of the Energy Secretariat. Their main duties are as follows: a) enforcement of concession contracts; b) to prevent anti-competitive or discriminatory behaviour; c) to take part in the selection of new concessionaires d) to organise public hearings to clarify conflicts between the parties; and e) to protect the environment and public safety from the activities in the electricity sector.

3.3.4 System operation after the reforming

Privatisation revealed a certain interest in purchasing public assets on the part of local and foreign investors. However, prices offered were far below the assets' replacement values, and represented a meagre collection for the State, which in some cases took responsibility for the previous debts of privatised public companies specially the long-term ones.

Besides their interest in existing facilities, private companies are being quite dynamic regarding both energy production and capacity expansion, except for power transmission.

In the oil industry greater impetus is noted in up-stream activities. Actually, crude oil production grew 49% (equivalent to 8.3% per annum) in the last 5 years. With a 39% share in 1995, exports propelled oil production, as the petroleum products' domestic consumption only grew 12% in the last five years, as seen in Section 3.2 above.

Even when oil companies disclose substantial investments in exploration, the 1995 proven reserves of crude were similar to those recorded in 1980. Consequently, the activity's expansion tends to reduce the reserves/production ratio, whose present horizon is limited to 9 years.

The domestic production of petroleum products, in turn, has remained practically unchanged from 1990 levels and the additional consumption in the 5-year period (12%) was supplied by imports, without this necessarily reflecting a lack of local refining capacity.

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 reducing imports from Bolivia.

Oil companies seem to be interested in expanding their activities in the country, as clearly evidenced by the ongoing search for new markets to sell their production. Particularly, as domestic final consumption of natural gas is closely tied to the economic performance, oil companies have been actively expanding the use of gas in power plants and seeking foreign markets for domestic natural gas. Because of the size of the market and its location with respect to reserves, the first exporting agreement was entered into with Chile.

Electricity generators have also been very active since 1992. After the restructuring about 3400 MW of additional generating capacity were installed in 3 years —one third of 1995 peak load— increasing reserves to 57% of peak load. However, 61% of the additional capacity came from hydropower plants already under construction with public funds before the restructuring.

Precisely, the coming on stream of such hydropower plants caused a noticeable drop in electricity spot prices, a trend that will prevail in the near future thanks to the progressive incorporation of additional units in Yacyretá hydropower plant. Despite this unfavourable environment in the electricity market, which could have discouraged private investors, companies started operating 1300 MW in gas-fuelled power plants without which the system's normal supply would not have been altered.

The power plants installed between 1993 and 1995 presented substantial operational advantages relative to the existing fossil-fuelled power plants. The main advantage was the availability all year round of natural gas at lower cost, rather than a much higher thermal efficiency than that of existing plants. In effect, the average heat rate of the power plants incorporated until 1995 amounted to about 2600 Kcal/kWh, which in spite of being low for open cycle gas turbines exceeds that of many displaced steam turbines.

Initially, most private investments were sited in the Comahue area to take advantage of low cost natural gas availability in the region. Proof of private investors' clear perception of this competitive advantage is that 69% of the capacity added until 1995 by the new gas-fuelled power stations is installed in the Comahue. Of those, practically 50% are wellhead power stations built by oil companies to use vented natural gas.

However, additional generating capacity in Comahue, both gas-fuelled and hydro, soon rendered evident transmission problems, reducing some local hydro operators' benefits. Complex mechanisms to expand the transmission capacity and diverging interests by generators have delayed the works for the fourth line in the Comahue-Buenos Aires lane.

As from 1995, competition between generators shifted from attracting customers in the contract market to improving competitiveness through new investments. Firstly, additional generating capacity was concentrated mostly in the northwestern region (NOA) especially the province of Tucumán, where natural gas is also available all year round at low cost and less restrictions exist on the transmission network. Some of the local facilities are already operational and the rest will follow soon.

Secondly, generators in large consumption centres are interested in improving their competitiveness vis-à-vis new generators, by enhancing thermal efficiency and buying gas at competitive prices. The advantage lies in having no transmission constraints and lower transmission costs. Such strategy is common to some Greater Buenos Aires' gas-fuelled power plant operators and local gas transmitters and distributors. Among the former, are the operators of the Costanera Power Station, who have completed a combined cycle taking advantage of an existing steam turbine, as well as the Puerto and Dock Sud operators who have contracted the installation of new combined cycles in their power plants.

Additionally, a company related to natural gas transportation and distribution in the metropolitan area has started the construction of a new high-efficiency combined cycle power station in the suburbs of Buenos Aires which may enter into an advantageous gas supply contract with the same holding.

As noted, oil companies' initial impetus in expanding generating capacity is driving greater competition between generators, encouraging new investments, which occur amidst downward electricity market prices sustained by generators-driven over-capacity in their search for improved competitiveness.

Such process is leading the electricity industry to a growing dependence from natural gas, regarding both availability and price. Considering that oil companies govern natural gas market, the generators' behaviour means, in fact, the reversion of the historical policy aimed at achieving the electricity sector's independence from the oil industry.

The regulatory reform resulted also in significant increases in electricity and natural gas retail rates, even when the government granted subsidies to private concessionaires to attenuate price increases at the beginning of the concession period. Such subsidies were progressively eliminated through higher rate increases to subsided consumers. In the case of electricity, such increases were less noticeable thanks to the drop in the spot market price. On the contrary, natural gas wellhead average price, presently deregulated, rose 23% between 1989 and 1995. During 1996 the upward trend continued (4.3% increase) and the average annual price weighting the 3 gas basins reached 1.22 US$ by million BTU. It should be mentioned that winter wellhead prices exceeded the average annual price by almost 5%.

In the case of petroleum products, the rules of the game tend at aligning domestic and international prices. In spite of the 34% decrease in the WTI oil barrel price between 1985 and 1995 at the international market, the domestic motor fuel prices grew up, especially premium motor gasoline whose end-user price increased 40% in the same period. However, premium motor gasoline price increase was much higher for oil companies in the same period (100%) because the State renounced to collect part of the oil rent by decreasing taxes levied on the marketing of gasoline.

It could be argued that such increases were due to differences between domestic and international prices before the restructuring. However, recent oil companies' pricing

policy for petroleum products has generated a number of conflicts with the government, who understood that the rise in domestic prices was contrary to the international market situation. In this case petroleum products' imports do not act as a regulating mechanism, as domestic oil companies exert a strong marketing oligopoly as will be discussed in the next section of this report.

Within this general context, the State as a regulatory authority responsible for defining energy policy still maintains the following powers, which reduce energy operators' autonomy in designing their business strategies:

- to define the energy policy and chose the mechanisms for its implementation;
- to regulate the inter-country trading of energy;
- to protect the environment.

To date, thanks to a relatively favourable context, the government's attitude towards the energy policy is flexible, especially regarding the use of domestic energy resources. However, the government is legally empowered to manage energy resources in general and hydrocarbons in particular, on this basis it authorises or licenses areas for exploration and production to private operators.

The government has promoted increases in hydrocarbons' production, especially oil, without substantially restricting domestic oil exports. Such policy might be reviewed if the present low reserve horizon persisted, particularly affecting exports.

As for crude oil, since the deregulation each field's operator can freely run their production. Free oil availability exceeds the domestic market and comprises also exports and eventual imports, which are not taxed at all. Field operators enjoy also free availability of foreign currency equivalent to the 70% of their total sales both in the foreign and domestic markets. Foreign trade deregulation affects petroleum products as well, although in such case a permit should be requested and granted by the State in a strict 7-day deadline.

It seems unlikely that such conditions, which actually served as the legal basis for oil activities' privatisation, will radically change in the short term. Eventually, exceptional restrictions could be imposed if the domestic supply were jeopardised, as proposed by certain sectors in the debate of the new Hydrocarbons Act. Such situation would only arise if certain operators' exports force refineries and/or consumers to import oil to meet their needs in a context of high international market prices.

The expected evolution of the international oil market turns unlikely a move in such direction, except for the impact of a specific conflict as the Gulf War. Consequently, the major constraint on Argentine crude exports' expansion and, therefore, for local production, is the limited reserves horizon especially for the most dynamic producers, as discussed in the next section,

Regulations on inter-country trade for natural gas and electricity foresee a governmental authorisation for each exportation project. From the conditions imposed on gas exports to Chile by the Argentine government, the goal seems to be not to alter the domestic market supply.

Regarding gas transportation the condition was to separate the gas pipeline to Chile from the trunk gas pipelines supplying the domestic market. Such situation called for building loops in the national gas network to prevent its capacity reduction. Should the same criterion be applied, the economic feasibility of projects for gas exportation to

Uruguay and Brazil would be affected. As the government is furthering exports to Brazil, it is unlikely that such criterion be strictly applied.

Contrarily to the oil market, natural gas export commitments have a long-term horizon and therefore sufficient reserves are required to meet this additional demand without affecting the domestic market supply in the long term. The government's attitude on this issue was less stringent than regarding gas transportation in the export project to Chile, as only the present supply conditions were analysed instead of making a 20-year prospective study of the domestic market. Consequently natural gas reserves shall also play a significant role in making exports feasible, although the State can resort to legal mechanisms to hinder them.

3.4   Major energy operators

As from privatisation many new companies were created with some Argentine economic groups as partners, mainly in the gas and electricity industries and to a lesser extent in the oil industry. A better understanding of the system's present business structure may help foresee the companies' business strategies, which will drive the sector's development in coming years. In the summary below, acting companies have been distinguished according to the following two criteria:

- by energy industry: gas, oil and electricity
- by process within each energy chain. Producers and purchasers are analysed in each market, although in some cases transmitters and traders have also been considered.

3.4.1 The gas industry

Gas reserves are distributed in five basins located far away from major consumption centres, which can be grouped into three regions: Neuquina, southern and northwestern. In terms of gas volumes injected into trunk gas pipelines, the Neuquina region is the most important with a share close to 51%. The remaining two regions contribute around 25% each and are much farther from consumption centres.

Two companies run the trunk gas pipelines on a regional monopoly basis: the Northern and Southern Transmitters (TGN and TGS respectively). Given both the network topology and the relative production volume in each basin, TGS transports about 63% of the gas injected into pipelines.

Some large gas producers sell their production through third parties instead of selling directly in the wholesale gas market. Such is the case of the second-larger producer (Total Austral) whose production is sold by the former public oil company (YPF), which markets also the gas imported from Bolivia (Yabog). We shall therefore talk about gas suppliers in the wholesale market distinguishing them from producers.

Even if gas supply was becoming more dispersed in later years, supply was still highly concentrated in 1996, as a single company (YPF) accounted for 56% of the gas injected into gas pipelines. The following two trading groups (Bridas-Astra and Perez Companc) added up to over 78%, and considering only six operators (plus Tecpetrol, Santa Fe and Quintana) 90% is exceeded.

Regarding purchasers, large consumers supplied directly by transmitters accounted for some 9% of the total 1996-sales, while the remaining 91% was purchased by the 8 gas distributing companies through contracts.

In terms of the volume purchased, the first distributor is Metrogas (close to 26%); the second is Camuzzi Gas Pampeana, (14%) and the third position is shared by Gas Natural BAN and Camuzzi Gas del Sur, (close to 12% each). Jointly these four distributors (three business consortia) account for near 63% of the total. The following distributors complete the list, in decreasing order: Litoral Gas, 11%; Gasnor, 7%; Centro, 5%; and Cuyana, 5%.

The distributors share in the gas market has remained stable in late years even when gas consumption grew faster in the northern and Cuyana regions the same as direct sales from transmitters to large consumers.

As some gas producers sell through third parties, the natural gas production is less concentrated than supply. The former public oil company (YPF) still ranks as the first gas producer but at a lower share. The four major producers contribute 72% of the 1996 natural gas domestic production.

In 1996 the gas reserves amounted to 688300 Mmm^3 which in terms of that year's production would yield a horizon close to 20 years. During the last two years, gas reserves grew 28%, thus reversing the decreasing trend of the 1989/1995 period. In spite of this reserve increase, the exports to the central region of Chile meant an additional pressure on the Neuquina basin, which is also the main supplier of the domestic market. Unless new reserves are discovered in this basin, the supply of domestic market will relay on gas production from the southern basin in the future, thus forcing to expand the trunk pipelines network.

Considering that each company's reserves/production ratio defines its own horizon in the gas fields it works, such ratio is a good indicator of their short-term-minded or conservative policies. To illustrate the production policy of each company, the prevailing situation at the end of 1994 is presented below, being the last year with data detailed enough for this type of analysis

The most critical situation in terms of own reserves would be that of Quintana and Perez Companc, with a 3.4 and 5.2 year horizon, respectively. In the case of Perez Companc, such time horizon is not consistent with its position as third gas producer in the country, a situation which the company will not manage to retain for long unless its own reserves are increased.

Pluspetrol, YPF and minor producers appear to have a more conservative management, with time horizons of 24.5, 20.3 and close to 70 years, respectively. Minor producers' long horizon shows that about 30% of the country's gas reserves, whose ownership is quite atomised, are not being worked at a significant pace.

When analysing the companies' share in the country's total reserves, the former public company (YPF) frankly ranks first, controlling 42.5% of total gas reserves. Actually, to equate YPF's reserves, the 8 companies that follow should pool theirs. Of those companies, only 5 have a share above 5% and none exceeds 9% of total reserves. The relative atomisation of gas reserves' ownership strengthens YPF's future role in natural gas markets, regarding production volumes and pricing.

To better understanding the strategies of energy companies and foresee their future behaviour is convenient to identify the economic groups that are their major shareholders. To that end, the gas transmitters and distributors' equity investment was analysed, as at December 1995. To illustrate activities' diversification in the gas

industry, wholesale market gas suppliers —and their respective share— are also included.

It should be pointed out that during 1997 international oil companies took over some local oil companies, but the firms remain active in the domestic market under their former denomination.

As no official information is available on these movements, Table 3 illustrates the situation prevailing at the end of 1995.

The first column to the left in the table bears acting companies' names. The gas industry concessionaires, two trunk transmitters and 8 regional distributors, appear in the heading. An initial column has been added for suppliers.

Each crosspoint of the double entry table represents the indirect equity investment (in %), i.e. when a company is part of a consortium with capital investment in a concessionaire, the percentage expressed results from each original firm's share times the consortium's share in the concessionaire.

The table includes 35 companies. As illustrated in subsequent sections, 18 of them (over 50%) also act in some of the other two energy industries: oil and electricity. The 18 firms —by activity— are the following:

- *oil and electricity*: Astra, Capsa, Perez Companc, Tecpetrol (Techint), Pluspetrol, Sociedad Comercial del Plata, British Gas
- *oil*: Bridas
- *electricity*: The Argentine Investment Co., TCW Americas Development, Enron Pipeline Co (proposal to install gas turbine), Cartellone Construcciones Civiles, Cía. Consumidores de Gas de Santiago (Chilean electricity companies owned by the same holding), Sideco Americana SA (Macri holding), Tractebel, Iberdrola, Camuzzi holding, Citicorp Equity Investment

The only gas suppliers participating in other processes within the gas industry are Perez Companc (transportation and distribution); Astra (distribution) and Techint (transportation. Only three companies participate in both transportation and distribution, i.e. Sociedad Comercial del Plata (non-marketing producer); The Argentine Investment Co.; and Argentine Private Developments. On their part, Sideco Americana (Macri holding); Societa Italiana per il Gas; the Camuzzi Gazometri holding; Citicorp Equity Investment; Loma Negra; and Pacific Enterprises International participate in more than one gas distribution concession holder.

3.4.2 The oil industry

The former public company (YPF) is the absolute leader also in crude oil production, with almost 43% share and more than tripling the country's second oil company's production (Perez Companc). In spite of YPF's major role, crude oil's domestic production is less concentrated than that of natural gas. The five major crude producers contribute 74% of the local supply, whereas the first five companies produce 85%.

Table 3   *Equity investment in the gas industry,* in % relative to the total (*)

Major Owners and Technical Operators (TO)	Wholesale Gas Suppliers % of total supply	Transport		DISTRIBUTORS								Notes
		TGN	TGS	GASNOR	CENTRO	CUYANA	LITORAL GAS	GAS NA-TURAL BAN	METRO-GAS	CAMUZZI GAS PAMP.	CAMUZZI GAS SUR	
YPF	64.10											
1-Bridas-Astra; 2-Astra-Capsa	11.50								14.00			1-Supplier.;2-Metrogas
Perez Companc-Bco Río-APDT	10.90		17.50						17.50			
Techint	5.70	15.60										
Pluspetrol	2.60											
Quintana	1.80											
CMS Gas Arg. Company		25.00										
SCP-CGC-Transco Gas Inv.SA		15.60						17.50				Soc.Comer.del Plata
Nova -Novacorp-(TO)		14.42										Canadian
Petronas-Petronas Arg.		10.50										Cía est. Malasia.Petroliam
Tha Argentine Investment Co.		8.09					8.82					National Berhad
Fima Finance Management		3.20										
TCW Americas Development		2.60										
Enron Pipeline Co. Argent.(TO)			17.50									
Cía Inv. en Traspor.de Gas SA			17.50									
Cartellone Construc. Civiles				36.00								
Cía Cons.Gas de Santiago (TO)				36.00								
Banco Francés				18.00								
Sideco Americana SA					67.50	45.00						
Soc. Ital. per il Gas (TO)					22.50	15.00						
Powerfin							22.50					
Iberdrola							21.00					Spanish
Tractebel (TO)							19.50					Belgium
BISA							9.18					
Sigas SA							9.00					
Gas Natural Int. Ltd (TO)								37.80				
Manra SA								14.70				
British Gas PLC (TO)									28.70			
Argent Private Dep.			17.50						9.80			
Grupo Camuzzi Gazometri (TO)										35.70	45.90	
Loma Negra										12.66	16.28	
Citicorp Equity Invest										8.75	11.25	
Pacific Enterprise Intern.										8.75	11.25	
Others	3.40		25.00						18.13	4.14	5.32	
Federal State			2.00					20.00	1.87	20.00		
Province						30.00						
Participative ownership program		5.00	3.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	
Totals	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	

(*)   Indirect participation (at 31/12/95): When a company is a part of a consortium with capital investment in a concession holder, the percentage expressed results from each original firm's share the consortium share in the concession holder firm

56

Oil reserves amounted to 358140 Mm³ in 1994. The reserves/production ratio (depletion horizon under present conditions) was only 9 years for the total, less than a half of the gas production horizon.

Taking each company's own reserve horizon as a policy indicator, the shortest-term-minded strategies pertain to Total Austral (3.8 years) and Petrolera San Jorge (5.5 years). Among the most conservatives are Amoco (12.1 years), others (11.5 years) and YPF (10 years). The values are smoother than those of gas, with a much lower interval between the highest and lowest values: 8.3 years for oil and 66.4 for gas.

As both energy products are linked, the same companies have a dominant position in both natural gas and oil production. However and depending on the features of the fields they work, their own oil reserves' horizon differs from that of natural gas.

In such sense, Perez Companc presents the most dissimilar situation. Its oil horizon is 40% higher than that of gas, opposing the national situation in which the gas horizon is twofold that of oil.

In the other end are minor oil producers. Although their horizon is 25% higher than the oil's national average, it accounts only for 16% of their gas timeframe. This indicates that the exploitation of crude oil fields is at a smoother pace than that of natural gas.

Regarding domestic crude oil reserves, YPF accounted for 46% of the 1994 total. YPF's predominance becomes clearer when observing that the remaining reserves are highly atomised. In effect, the 14 companies that rank after YPF would have to pool their reserves to match its share. Such values confirm oil reserves' greater dispersion relative to natural gas, where YPF's reserves equal those of the 8 companies that follow in the ranking.

As for petroleum products' production, the three companies traditionally related to such activity ranked first: YPF (53%), ESSO (17%) and SHELL (15%). Said companies accounted for almost 85% of the crude oil processed in local refineries. The remaining 6 companies' share was notably lower.

Among the first three companies in petroleum products' production, only YPF has a significant presence throughout the oil chain.

3.4.3 The electricity industry

As stated in Section 3.3 above, the restructuring of the electricity industry in Argentina was achieved by atomising the national public companies' assets, thus allowing 45 private companies to emerge in the three stages of the electricity chain. To the 26 electricity generators created through privatisation of existing facilities, 8 additional generating companies were added up through an equal number of new power stations installed by private investors, already operational or expected to enter into the grid soon.

Besides the generating business units, 6 transmission companies were established (one for extra-high voltage and 5 for regional transmission). Recently 2 additional transmission companies entered into the market as independent transmitters related to the extra-high voltage grid, in charge of building and operate the transmission system of Yacyretá hydropower station (HPS).

As for power distribution, 22 distributors were operational in 1995, excluding electricity co-operatives. Thirteen were private whereas the remaining 9 were owned by the respective provincial states, although some of them were privatised later on.

Some consortiums formed to participate in a specific bidding process turned into a permanent association for other privatisations. In many cases the consortium itself has been granted more than one business unit, although not always formed by all the same members. The following illustrate such statement:

Enersis-Pérez Companc-Entergy (1 thermal power station and 1 distribution concession); EdF-Nucleo Inversor-Banco de Galicia (2 hydropower stations and 1 regional transmission company) IATE-Eleprint-FATLyF (3 thermal power plants, 2 regional transmission companies and 1 distribution concession).

Additionally, some geographic specialisation is clear, with companies prevailing in certain regions of the country.

The Patagonian power system, the only still isolated from the main network (SADI), is controlled by the following three groups: IATE-Eleprint-FATLyF; Camuzzi-Electricity Co-operatives; and ALUAR. The first group was granted the license of gas-fuelled power stations (242 MW). The aluminium producing company ALUAR holds the concession of its supplying hydropower station (Futaleufú; 448 MW). The Camuzzi-led group holds the concession of another hydroelectric power plant (Ameghino 48 MW). Regional transmission is in the hands of ALUAR and the Camuzzi-led group, while distribution is undertaken by electricity co-operatives. It should be emphasised that Camuzzi —a local gas distributor— recently opened a new 77 MW gas-fuelled power station to meet regional demand, in this case associated with the Amoco oil-company.

In the Northwestern region (NOA), The Light and Power Worker Union (FATLyF) is the major company. By its own, It holds 90% of some thermal power stations (249 MW distributed all over the region) and in association with IATE runs the regional transmission network. However, the hydropower stations were granted to two other consortiums (172 MW), the Güemes power station (245 MW) was bought by a consortium led by Duke and Comercial del Plata and last year oil companies decided to install 3 new gas-fuelled power stations in the area. Among the 5 provincial electricity distributors recently privatised only one was won by IATE, an important FATLyF's partner. Exxel, Houston and Cartellone own the other 4 private northwestern distributing companies. Even when FATLyF obtained a minor share in one of these companies, its position seems to be weakening in the region.

IATE prevails in the northeastern region (NEA), either by itself or associated with other companies, excluding of course the Yacyretá hydropower station, of a binational character. IATE has a share in 3 thermal power plants (553 MW), leads the consortium holding the regional transmission license and won the concession for one distributing company, the only one run by the private sector in this region. As IATE's thermal power plants cannot operationally compete with Yacyretá, its role in the area will mainly be geared to regional transmission and distribution.

Since the last privatisations, Electricitè de France (EdF) gained a strong position In the Cuyo area when it was granted the concession for two hydroelectric complexes (627 MW) and the regional transmission. The remaining regional generation (483 MW, 80% thermal) is in the hands of two North American companies, CMS and AES. As for distribution, there is one provincial company (Mendoza) and the other (San Juan) was granted in concession to a consortium led by the Chilean company Chilgener. Scarce local natural gas reserves and reluctance to invest in new hydropower stations, a resource broadly used in the region, make it difficult to foresee substantial generation investments in the area, which, on the other hand, is strongly interconnected to the

main network (SADI). EdF is also the technical operator of EDENOR —one of the metropolitan distributing companies— in which it holds a minor share (9%).

Less clear is the regional specialisation in the country's central area and in Comahue, where most of the electricity demand and supply are concentrated. In this case, 2 Chilean companies have been especially active: ENERSIS (with a majority share in ENDESA and Chilectra Metropolitana) and Chilgener.

ENERSIS, in a partnership with Perez Companc, became active in the country from the very beginning of privatisations, when became the owner of the major thermal power station in Buenos Aires (1260 MW) and was granted the concession of one of the metropolitan distributors (EDESUR). The Chilean group is the major shareholder in both consortiums, thus frustrating the government's intention to hold electricity generation and distribution independent, especially considering that as a privatisation condition this distributor has a commitment to purchase power from the power station owned by the same group.

Although such contract guaranteed the gas-fuelled power station a highly profitable operation, the closeness to its expiry (year 2000) pushed the Chilean group to improve its electricity generation competitiveness. The first step was to obtain the concession to run one of the country's major hydroelectric complexes (Chocón 1320 MW), having the American CMS as a partner and excluding Perez Companc. More recently, they invested to complete a high-efficiency combined cycle in their thermal power station (340 MW) and planed to install a new 830 MW combined cycle, retaining their partnership with Perez Companc.

Chilgener, based on its experience in Chile, initially concentrated on generation by purchasing the second thermal power plant in Buenos Aires (1009 MW) under conditions similar to the one bought by ENERSIS. In this case, however, no partnership was established with any Argentine company.

Chilgener's strategy for the local market was similar to its Chilean competitor's. Firstly, it diversified their production structure by acquiring the concession to run the Comahue's most important hydropower station (Piedra del Aguila: 1400 MW), in this case in association with the Canadian firm Transalta and the American Duke, despite a minor shareholding by Perez Companc.

The first step towards improving its thermal production's competitiveness was to install a new gas-fuelled power plant in the Comahue area (375 MW open-cycle gas turbine) benefiting from natural gas' lower local price. More recently it has contracted the construction of a combined cycle (382 MW) in its Buenos Aires power station, thus avoiding transmission costs and restrictions in the Comahue-Buenos Aires lane.

It has only very recently engaged in electricity distribution, when it was granted the distribution concession in San Juan, a province on the border with Chile, in a partnership with a Chilean distributor. Although this retail market is not very relevant, such action suggests Chilgener's interest in a further vertical integration of its activities in the country, an intention evidenced from the very beginning by the ENERSIS group.

Chilgener is also installing a new gas-fuelled power station in the northwestern region (600 MW) to supply —in principle— the north of Chile. In such sense the Chilean companies may play an active role in both countries' electricity and energy integration in the future. Actually, Chilgener promoted the construction of the gas pipeline to Santiago de Chile, as a part of its competitive strategy with ENDESA for the control of

the Chilean wholesale electricity market. Chilgener's recent interest in the electricity distribution in San Juan may be also related to its position in the Chilean market. The Argentine distributing company may enlarge the market for the new power stations that Chilgener intends to install in Chile to profit the natural gas imported from Argentina.

Notably, neither Chilean group has shown any interest in participating in the transmission business. As already mentioned, regional transmission was captured by companies who defined a regional concentration strategy for their activities. On the other hand, the concession to run the existing extra-high voltage grid was granted to a consortium in which two Argentine oil companies (P. Companc 16% and Comercial del Plata 10%) and two American companies (Entergy 10% and Duke 10%) hold shares.

The case of Perez Companc should be further analysed. Even with a minor equity investment and generally in association with Chilean companies, it soon evidenced its intention to participate in all the electricity industry processes. Thus, it participates in generation (12% C. Costanera and C. Buenos Aires; 2% C.H. Piedra del Aguila); distribution (17% EDESUR) and in extra-high voltage transmission (16% of TRANSENER). Through its building company (SADE) it also holds 22% of the shares of the independent transmitter established for the construction of the 500 kV Yacyretá-Resistencia line.

However, its position as natural gas transmitter and distributor seems to incline it to play a more active role in electricity generation, as may be concluded from its decision to build a new power station in the outskirts of Buenos Aires (660 MW combined cycle). Other oil companies acting in the gas industry seem to share Perez Companc's strategy.

One of the electricity industry's features after the restructuring has been the low impetus in expanding and adapting the extra-high voltage network. The consortiums in charge of constructing and operating the two already granted Yacyretá transmission lines seems to indicate that the construction companies having experience in the area will play a central role as independent transmitters. Among Argentine companies, both Perez Companc through SADE and SOCMA through SIDECO appear better positioned, although perhaps in the future Techint may also participate. The good perspectives of these Argentine companies would not exclude the participation of foreign companies that have previously been active in the country (Impregilo, Dumez, Polledo, etc.).

The American companies that act in the country after the privatisations evidence a higher specialisation by electricity industry process, especially those that are major shareholders in the consortiums awarded the concessions. Thus, while Dominion, Duke, AES and Southern have concentrated in power generation, generally in more than one single power plant, the Houston and Exxel Group are more geared to electricity distribution. Only CMS dominates in both activities (51% Mendoza thermal station and 36% distribution in Entre Rios), while Entergy participates in all processes as a minority shareholder.

Besides the role played by the companies in privatisations, the present dynamics of the industry and its future perspectives should be analysed. Firstly, generating capacity expansion is growing oriented to high efficiency combined cycles burning natural gas. The initial trend to benefit from competitive advantages in sites close to gas fields (initially Comahue and later the northwestern region), seems to be shifting to install

new power stations in electricity consumption centres with higher prices for electricity in the WEM and less restrictions on the transmission system.

In all the cases —power stations close to gas fields or consumption centres— the major business opportunities are offered to companies that can gain comparative advantages in fuel supply. From such standpoint, gas transportation and distribution companies start to play a role in the expansion of generating capacity. Opportunities are even larger when such companies also have a share in gas production, e.g. Perez Companc.

On the other hand, the electricity industry vertical reintegration, especially linking generation and distribution, seems more relevant for companies that own the less competitive power plants. Their expansion appears somewhat blurred when compared to companies that share in the gas industry. Even though electricity distribution was a less profitable business than generation in the last years, there are fewer competitors despite the large users' market opening up, and therefore less business risks are involved than in generation.

Finally, electricity generation's growing dependency on natural gas, which will become even more evident in coming years when the market fully absorbs Yacyreta's substantial hydroelectric supply, strengthens the link among energy chains even more than under the State ownership. Consequently, purely electricity companies' strategies will probably depend on the natural gas market circumstances, regarding both availability and prices.

3.4.4 Interrelations between energy chains.
To more clearly visualise each firm's share in the various processes within a single chain, as well as their investments in the three energy chains —gas, oil and electricity— Table 4 lists major firms in alphabetical order, as well as their inter- and intra-relations.

The heading contains the three industries under consideration: gas, oil, and electricity. The double entry table shows major firms investments' size and importance in the three energy chains: intra- (within a single chain) and inter-relations (between several chains).

Besides the facts already discussed when analysing each energy industry and particularly the electricity industry, certain comments should be added about YPF's strategy, the major oil and natural gas company. After its privatisation, YPF did not evidence any interest in diversifying its domestic activities and has continued to play the role it had as a public company.

Differing from other oil companies, YPF does not participate in domestic natural gas transportation or distribution, but it has been very active in promoting natural gas exports. In partnership with other oil companies, it has recently pushed the construction of several gas pipelines. However, its primary interest seems to be in expanding the gas market through sales abroad rather than in supplying the gas transportation service.

Regarding electricity generation, YPF has not evidenced any interest in such market and entered into forward contracts with private generators to meet its electricity requirements.

Table 4   Inter-relations and intra-relations within energy chains

FIRM or GROUP	GAS	OIL	ELECTRICITY
* AES			- Hidroeléctrica Río Juramento: 98 % share - Hidrotérmica San Juan: 98 % share - CT San Nicolás: 36% share
* Astra	- Production-Supplier: jointly with Bridas 11,5 % of gas injected into trunk gaslines - Reserves: 3.30 % share - Distribution Metrogas: 14 %, with Capsa	- Production: 3.8 % of the total - Reserves: 3.1 % of the total - Refineries: 0.7.% of processed crude	- Distribution: EDENOR: 9 % share - Distribution: EDDER 18.90 % share - CT Filo Morado: 100% share
* British Gas	- Distribution Metrogas: 28.70 %		- CT Dock Sud: 45 % share
* Cammuzzi	- Distribution Gas Pampeana: 36.30 % share - Distribution Gas del Sur: 36.30 % share		- CH Florentino Ameghino: 35 % share - Transporte: Transportadora Patagónica: 20 %
* CMS Electric & Gas Co.	- Tansport: TGN 25% share		- CH Chocón y Arroyito: 14.8% share - Cs.Ts. Mendoza: 51% share - Distribution: EDDER-E.Ríos: 36 % share
* Cartellone CC	- Distribution: GASNOR-Distribuidora de Gas del Norte 36.0 % share		-500 kV Transmission: LITSA , intercon..Yacy-retá-Salto Grande-Posadas - Distribution: EDET-Tucumán: 64.5% share
* Citicorp	- Distribution Gas Pampeana: 8.8% share - Distribution Gas del Sur: 11.3% share		- Distribution EDELAP: 12.7% share - CT Dique: 12.7% share
* Chilgener			- CT Nuevo Puerto + Puerto Nuevo: 30% share - CH Piedra del Aguila: 16,40 '% share - CT Neuquén: 33% share - Distribution San Juan
* Comercial del Plata	- Reserves : 0.7% - Transport: Transportadora de Gas del Norte TGN: 15.6% share - Distribution Gas Natural Ban (GASBAN) 17.5% share	- Reserves: 0.4% of the total - Refineries: 2.% of processed crude	- CT Güemes: 15% share - 500 kV Transmission: Transener: 9.8% share
* Duke			- CH Piedra del Aguila: 9.8% share - CT Güemes: 15% share - 500 kV Transmission: Transener: 9.8% share
* Dominion Energy			- CH Cerros Colorados: 38.4% share - CT Alto Valle: 54% share
* Enersis			- CT Costanera y Bs.As.: 42% share - CH El Chocón y Arroyito: 34.4% share - Distribution EDESUR: 64.2% share
* Eléctricité de France			- Hidroeléctrica Los Nihuiles: 23.5% share - Hidroeléctrica Diamante: 29.5% share - Transport: Distribución Troncal Cuyo: 20.9% share - Distribution: EDENOR: 9% share
* Houston Industries			- CT Dique: 16.6% share - Distribution EDELAP: 16.6% share - Distribution: EDESE-Sgo.Estero: 90% share
* Iberdrola	- Distribution: Litoral Gas: 21% share		- CT Güemes: 12% share
* Iate SA			- CT Sorrento: 18% share - Cs.Ts.del Litoral: 45% share - Cs. Ts. del NEA: 90% share - Cs. Ts. Patagónicas: 17% share - Transport: Transnoa: 21.8% share - Transport: Transnea: 24% share - Distribution EDECAT (Catamarca): 90% share - Distribution:EDEFOR (Formosa): 30% share
* Perez Companc	- 3rd Gas Producer: 10.8% of the total - 3rd Gas supplier: 10.9% of the total - Reserves: 3.3% of the total -Transport: TGS 17.5% share -Distribution: METROGAS 17.5% share	- 2nd Producer: 12.2 % share - 3rd place in Reserves: 8.9% of the total - Refinery (REFINOR): 28% equity investment 3.1% of processed oil	- CT Costanera y Bs As: 12% share - CH P.Aguila: 2% share - GENELBA - 500 kV Transport: Transener: 16.3% share - Transport: Yacylec 22.2% share - Distribution EDESUR: 16.6% share
* Techint	- 5th Gas supplier: 5.7% share - Reserves: 5.7% share - Transport: TGN 15.6% share	- Reserves:Tecpetrol: 4th place: 3.7% share	- CT Dique: 16.6% share - Distribution: EDELAP 16.6% share
* YPF	- 1st Gas supplier: 64% of the total - 1st Producer: 40.5% of the total - Reserves: 42.5% of the total	- 1st Producer: 42.6% of the total - Reserves: 46.3% of the total - Refinery: 52.3% of processed oil	

Such interrelations shall be further discussed when defining the expected evolution of the Argentine energy system for the baseline scenario. As stated in this report's Chapter III the elements presented herein shall help define the system's dominant players, whose role will be considered when analysing climate change mitigation

4 The environmental context

The Argentine public perception about environmental problems is changing fast. Toxic waste management, soil degradation and streams' pollution are more often an issue of public concern. On several occasions protests originated in energy sector activities (present or potential). The search of a final repository for nuclear wastes, oil spills in fields and some hydroelectric projects provoked public protests demanding greater environmental protection.

On the contrary, air quality does not seem to rouse general concern, except for toxic compounds' concentration in downtown Buenos Aires. In such sense, actions aim at controlling pollution from urban transportation, through emission control and fuel additives' regulation. It should be noted that Buenos Aires' climate and topography account for much cleaner urban air than other Latin American capitals (Mexico City and Santiago de Chile among others).

Public opinion seems to be less concerned by GHG emission, although a growing interest can be noted regarding climate change potential effects.

As a signatory of the UN Framework Convention on Climate Change, Argentina is preparing its National Communication Report to the Conference of the Parties which includes, besides the 1990 and 1994 GHG emission inventory, three specific analyses on vulnerability to climate change and a study on mitigation potential.

As expected, the inventory shows CO_2 emission's clear pre-eminence over the remaining GHG from energy production and consumption. In spite of the 12% increase in total CO_2 emission between 1990 and 1994, both the per capita emission and the emission intensity remain still far below the OECD average values (3.4 Ton CO_2/cap and 391.2 Ton CO_2/million US$ of GDP against 11.1 Ton CO_2/cap and 690 ton CO_2/million US$ of GDP, respectively).

Presently, 70% of CO_2 emission come from final energy consumption whereas the remaining 30% are accounted for by energy supply-related activities. The transport sector is responsible for 32% of total emission and its future consumption pattern will largely impact on 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.

In order to provide a broader historic perception, the following sections analyse 1970-1995 non-biogenic CO_2 emission from the energy system and their relation to energy policies. To compute such emission, energy data from the OLADE Energy Information System (SIEE) was used, but the emission coefficients per source and use were replaced for the values adopted in the Argentina's GHG inventory. Additionally, some criteria to calculate emission from natural gas supply were also changed following the criteria used for GHG inventory. Consequently, the results presented here-in-below represent an adjustment of the values appearing in "Energy and Environment in Argentina: Past and Prospective evolution" by IDEE/FB, published by UCCEE-Risoe in October 1994.

The IPCC methodology excludes biogenic emissions from biomass fuel combustion for the sake of national emission inventories from the energy system. To maintain consistency with the national inventory, only non-biogenic emissions are presented here. It should be noted however that biomass fuels' share was low throughout the whole period, below 6.5%. Although some biomass was substituted during this period

(presently accounts for only 4.4%), energy-related biomass combustion emission would not substantially alter the trends shown herein.

4.1 Total CO₂ emission evolution

Throughout the whole period, total CO_2 emission had a slightly upward trend, equivalent to an average annual rate of 1.5% along the last 25 years. As seen Figure 8, fluctuations occurred associated to economic movements and changes in energy supply, already discussed in previous sections. The following three sub-periods can be identified: 1970/79; 1980/90 and 1991/95.

Figure 8   Total CO₂ emission from the energy system
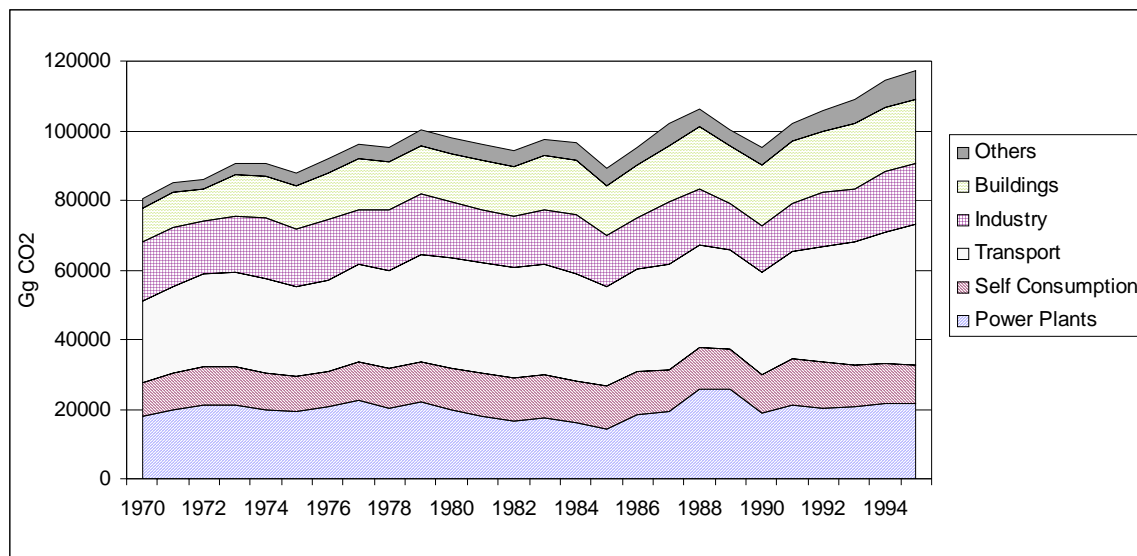
Between 1970 and 1979 emission grew at 2.5% annual rate driven by all sectors' increased energy consumption, except the industry. Industrial emission remained stable thanks to the substitution of liquid petroleum products, thus neutralising the effect of increased industrial energy consumption in those years.

The economic recession during the Eighties, mentioned in Section 2 above, would have resulted in greater CO_2 emission abatement had it not been for the strong increase in electricity power stations' fossil fuel consumption as of 1987 due to an extended drought. Precisely, until 1985 electricity power stations had contributed to mitigate emissions thanks to a higher share of hydroelectric and nuclear generation. Such process reverted by the end of the eighties with the consequences illustrated in Figure 8. During that decade energy consumption remained practically unchanged, except for the residential and commercial sectors, which increased their share in both total energy consumption and total CO_2 emission.

Economic growth in recent years activated both energy consumption and emission, which grew at a rate equivalent to 4.3% per annum between 1990 and 1995. Leaving aside agriculture and cattle breeding, whose contribution to total emission is scarce, the transport sector was the major contributor to increased emission (6.5% annually) due to both a higher motorization rate and a more intensive use of the automotive fleet.

64

During the last five years industrial emission increased by 6% per annum, at a slightly higher rate than its energy consumption (5.3% annually). Such behaviour seems to reverse the industrial sector's previous trend. Actually, in the previous 20 years industrial emission decreased by some 1.3% per annum despite the 0.6% annual energy consumption increase. These figures resulted from structural changes in the manufacturing industry during those years, and also the switching from petroleum products to natural gas for heat purposes. The last five years seem to indicate that the substitution process has reached its ceiling. Therefore, sustained industrial growth in Argentina should be expected to involve CO_2 emission increases. Although industrial emission will depend on the type of activity, such results emphasise the convenience of analysing mitigation options in this sector to prevent its relative share in total emission to increase.

When analysing changes in total emission sectoral structure illustrated Figure 9, it is noted that power stations' emission is increasing at a slower pace than the rest of the system. In spite of gas fuelled generation's increase in the last five years, its share is still well below the highest historical figures.

Figure 9   Total CO_2 emission by sector
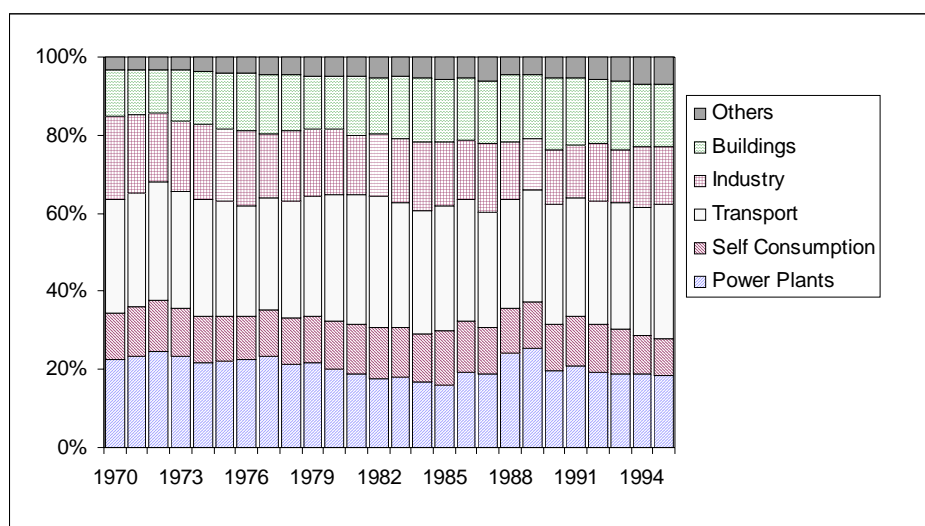
The residential, commercial and public sectors are losing share in total emission in later years, in spite of their constant energy consumption growth (3.5% annually between 1990 and 1995). However, saturation seems to affect petroleum products' substitution also in this case. Consequently, future emission evolution should be closely tied to energy consumption trends.

4.2   Evolution of CO_2 specific emission

To illustrate the energy system's environmental efficiency in Argentina, Figure 10 shows total CO_2 emission evolution per unit of energy supplied. Such values, identified in the figure as "Total", were calculated as a function of "non biogenic" gross energy supply. This means that the supply of biomass sources was subtracted from each year's total energy supply and the unused energy was added up.

As seen, the amount of CO_2 emitted from each Petajoule supplied shows a much clearer trend than total emissions. Total specific emission decreased persistently throughout the whole period being today 25% lower than in 1970. Such decreasing

trend was only interrupted between 1985 and 1989. In recent years it has been decreasing at a much slower pace than the one recorded until 1985.

Figure 10   Evolution of the specific CO_2 emission
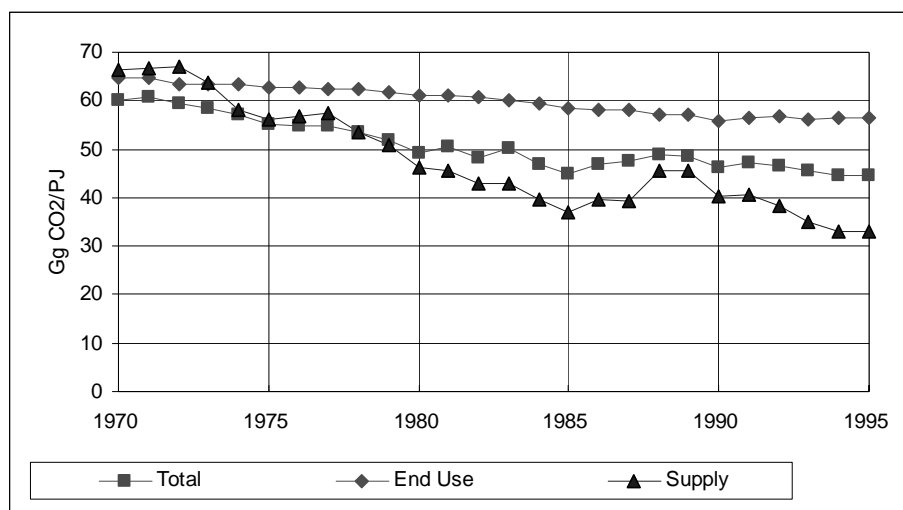
In order to visualise more clearly the factors that drove such behaviour, the same figure includes two curves representing the CO_2 emitted from each PJ consumed in final use sectors and in energy supply-related activities, respectively. Although final consumption's specific emission decreased by about 12%, it is clear that efforts made in energy supply have been key to attain such a remarkable decrease in total specific emission. Actually, specific emission from energy supply activities decreased 50% between 1970 and 1995 showing a persistent trend interrupted only between 1985 and 1989, that impacted also the total specific emission as shown.

Energy supply emission originates in two sources: fossil fuel combustion in thermal power plants and energy industries' consumption (self-consumption). As seen in Figure 11 specific emission abatement was driven by the power stations' 60% emission reduction during such period, although own consumption's emission also evidenced a slightly downward trend.

Because of the way in which calculations are made, a change in the average amount of CO_2 emitted evidence changes in the type of energy source used. When substitution is for a non-emitting source, like hydro or nuclear, the impact on specific emission is more relevant. Precisely the power plants' specific emission drop is mainly due to changes in generation structure, although switching from petroleum products to natural gas in thermal stations had also beneficial effects. Since 1985 conventional thermal generation's share started an upswing, which peaked in 1988/89 due to a strong drought, increasing specific emission as the figure shows.

To calculate such curves, hydropower energy was computed as the consumption of an equivalent thermal station so as not to artificially increase power plants' energy efficiency. The same figure illustrates the emission per unit of generation output (TWh), identified as "Power plants - Gen". The ratio between the two power plants' specific emission curves (Power plants - inputs and Power plants - Gen) yields the power stations' energy efficiency index. In such respect, average efficiency has increased in recent years due to thermal stations' renovation and some over-capacity that permits to shut down the least efficient power stations. Even if generators are

evidencing interest in improving thermal stations' efficiency, power plants' average specific emission is expected to grow in the future as a result of hydro and nuclear generation's lower share, in spite of burning almost exclusively natural gas in thermal power plants.

Figure 11   Emission from energy supply
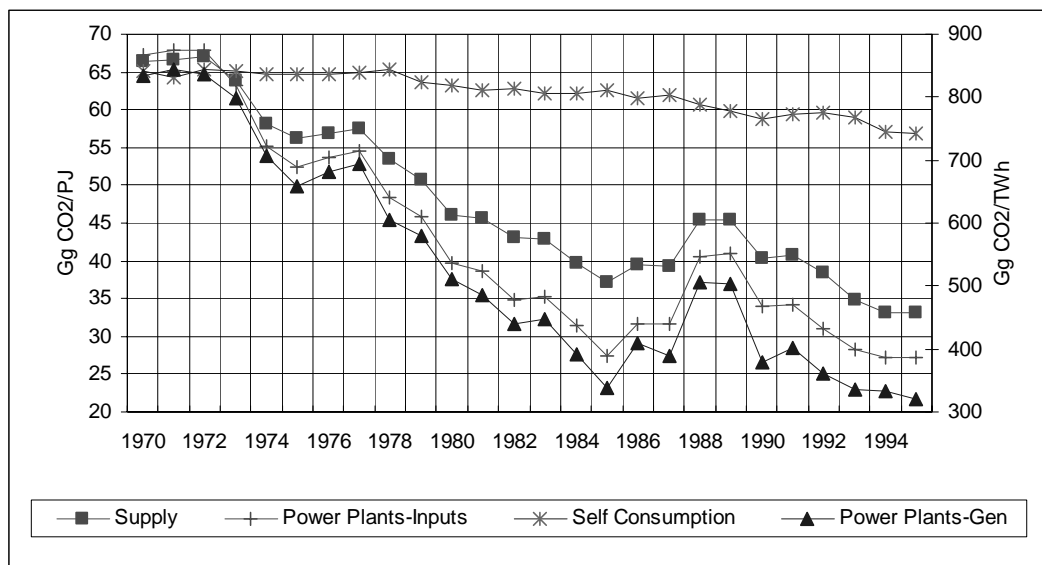
As for emission from final use sectors, uneven behaviours were also seen, as illustrated in Figure 12. The most important abatements occurred in the manufacturing industry, 29% between 1995 and 1970, although the trend seemed to have reversed as of 1990. As previously mentioned, this could be hinting at a certain degree of saturation in the substitution process between sources, although the industrial structure has a clear impact on CO_2 specific emission.

Figure 12   Specific CO_2 emission from final energy consumption
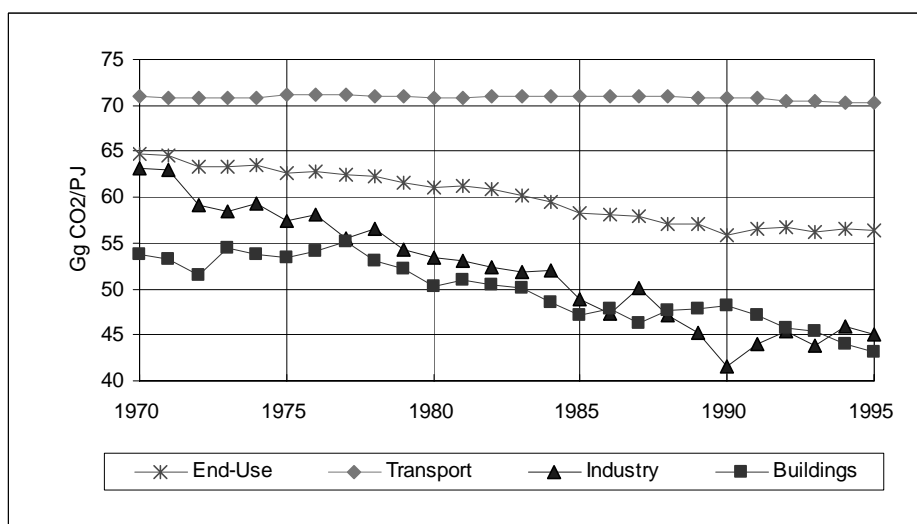
The residential, commercial and public sectors specific emission's abatements are lower than those of the industry (20%) and more stable in time. Both the natural gas' high penetration for heating purposes and electricity have also driven the specific emission decrease. In such sectors growing competition is noted between electricity and natural gas, especially in the production of cold (air conditioning and cold chain in large commercial centres). If more natural gas is used to replace electricity, the sector's specific emission will grow. However, the increase in final use emissions could be offset by lower emission in power plants, resulting in lower total emission provided gas-end-use-efficiency exceeded 45%.

The stability in transport's specific emission, illustrated in the figure, reflects the sector's rigid energy consumption structure by source. Incipient natural gas penetration has not attained sufficiently high levels to alter the sector's specific emission yet.

4.3   Energy and CO_2 emission pathways

The path followed by energy intensity (energy supplied per GDP unit) as a function of per capita GDP changes represents the country's energy pathway and allows to graphically relate energy consumption to economic performance. Similarly, the CO_2 emission pathway represents the emission intensity trajectory (emission per GDP unit) according to changes recorded in the per capita GDP. In Figure 13 both pathways are shown for Argentina in the 1980/1995 period, taking the respective 1980 intensities as the 100 index.

As seen, the Eighties' economic squeeze brought about energy intensity and emission intensity increases, 13% and 6%, respectively. However, both intensities' behaviour was remarkably different in both five-year periods.

While the energy intensity increase mainly occurred in the first period, emission intensity remained almost constant thanks to power stations' emission abatement and petroleum products' substitution in final energy uses. On the contrary, by the end of the '80s a steady drought caused fossil fuels combustion in power plants to rise dramatically, increasing emission intensity by 5% although energy intensity remained practically stable.

Figure 13   Energy and CO_2 emission path
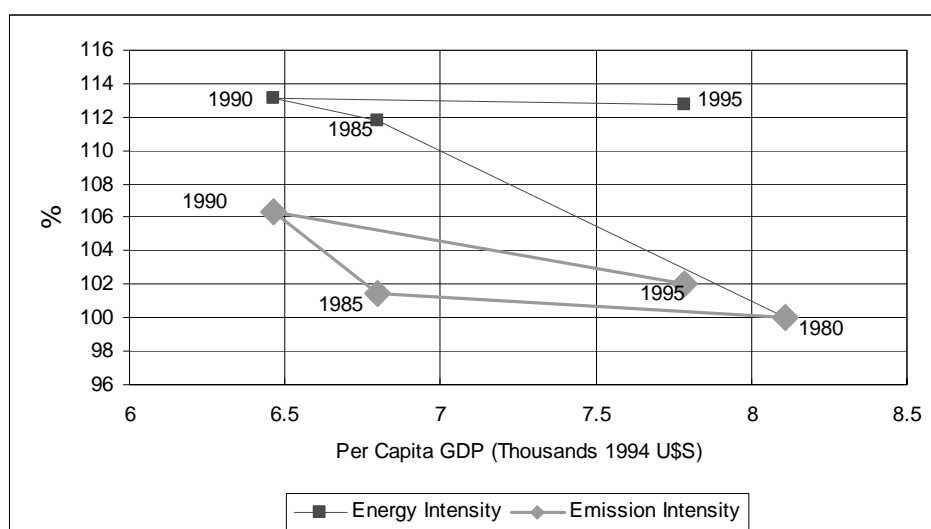
Recent years' economic growth did not impact Argentina's energy intensity. In spite of the greater natural gas penetration in end-uses, the larger hydroelectricity contribution and thermal power stations' increased energy efficiency allowed for some 4% emission intensity abatement, reaching a figure close to the 1980 levels.

Both curves' ratio represents the pathway followed by specific emission (emission per unit of energy supplied) as a function of economic performance changes, presented in Figure 14.

Specific emission's downward trend in Argentina persisted regardless of economic oscillations and was associated, as previously seen, with energy system's adjustments aimed at decreasing its dependence from petroleum products. Only in the 1985/1990 period a 3% increase occurred due to the above mentioned difficulties in power supply. Presently, specific emission is 10% lower than that of 1980.

Figure 14   Specific CO₂ emission path
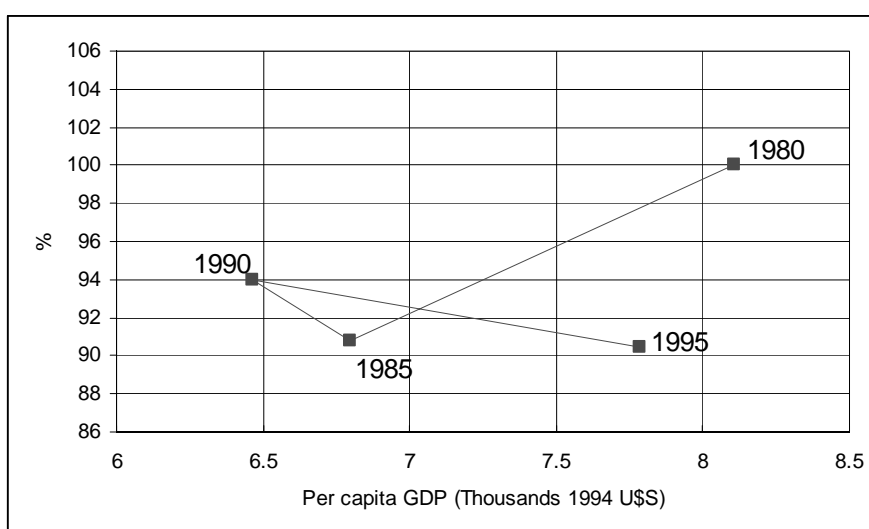
4.4   Conclusions

Given the present development of the energy system in Argentina, significant effort will be required in the future to moderate the effects of economic growth over total CO_2 emission. In spite of both the past efforts to improve energy infrastructure and the success attained in replacing liquid petroleum products, economic growth phases (the '70s and 1991/1995) resulted in total emission expansion.

Except for transportation, where natural gas use is still incipient, GHG emission growth will be difficult to moderate by substituting energy sources in final uses. In future, besides guaranteeing gas and electricity supply's ongoing expansion, energy efficiency will have to increase in all consumption sectors so as to retain the relatively low emission indexes achieved in the last 25 years.

As explained below, technological renewal can naturally occur in some activities, favouring increased energy efficiency. As for transportation, active policies to promote the use of less energy-intensive transportation means would be required, as the more intensive use of road transportation and particularly private cars, offsets improvements in vehicles' energy efficiency.

The emission evolution along the last 25 years clearly shows that changes in electricity generation structure were the key to moderate total emission growth. Had the 1970 power stations' specific emission been maintained, the 1995's total CO_2 emission would have risen 30%.

Under the new electricity industry's regulation it seems hard to maintain present emission rates in the future if thermal generation tends to recover the share it had in total generation until the beginning of the '70s even using highly efficient natural gas fuelled power stations. CO_2 emission perspectives are even less promising if inter-country exports, especially to Brazil and Chile, are added to domestic electricity consumption's high growth.

Some doubts have been posed on whether emission from exports should be allocated to the exporting or importing country. Although this is a controversial issue that could be raised in international negotiations on equity in climate change responsibilities' allocation, electricity exports in particular and energy exports in general, deserve no different treatment than any other tradable goods in the international markets.

Methodological approach

1 Introduction

This chapter summarises the methodological approach applied to the climate change mitigation analysis in Argentina. This report is aimed at specifying some adjustments performed to the general methodology for its application to Argentina rather than describing in detail the methodology used, presented in a number of documents from the Global Environmental Fund (GEF). Annex 1 includes some comments on additional adaptations needed to fit the institutional and regulatory features of the energy system in Argentina, specially regarding both the decision making criteria in formulating the *mitigation scenario* and implementation issues.

2 General methodology for mitigation studies

Following the methodological approach set forth by the GEF/WB for climate change mitigation studies two future scenarios of the system under analysis were compared. One of them *(baseline 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 GHG absorption capacity *(sinks)*. The second one (*mitigation scenario)* on the other hand, involves selecting a set of actions or options aimed at climate change mitigation, to assess the benefits derived from its implementation.

In addressing the analysis of the energy system's mitigation potential (energy supply and consumption), the scenarios are formulated on the basis of a *diagnosis* so as to better understanding economy-energy and energy-environment links, the dynamic of the economic and energy systems and their impact on atmospheric GHG concentration.

As illustrated in Figure 15, after the *diagnosis* stage and prior to formulating the *mitigation scenario*, the mitigation options available in the sectors under analysis should be identified and characterised. Actually, the *mitigation scenario's* building assumes pre-selecting the most attractive options to mitigate climate change effects.

Methodological Guidelines establish that national teams should define the criteria to pre-select mitigation options for the mitigation scenario, clearly hinting at the number of situations and preferences available to define a national climate change mitigation strategy.

Mitigation options assessment (analysis stage in Figure 15) has to be addressed on the basis of "costs" and "benefits" they offer vis-à-vis the situation expected in the *baseline scenario.* It should be noted that the definition of "costs" refers both to the additional economic resources that would have to be committed to implement the mitigation options contained in the scenario, and to any other sacrifice the whole society should undertake, or some of its members, to mitigate climate change. Similarly, and although the major benefit drawn from such options is their contribution to atmospheric GHG abatement, the term "benefits" should also be construed in its broad sense, to include other positive effects from mitigation measures.

The broadness of such concepts assumes a detailed analysis of mitigation options' impacts, the barriers to an effective implementation and the identification of mechanisms to overcome such obstacles.

Figure 15   Analytical stages for mitigation studies
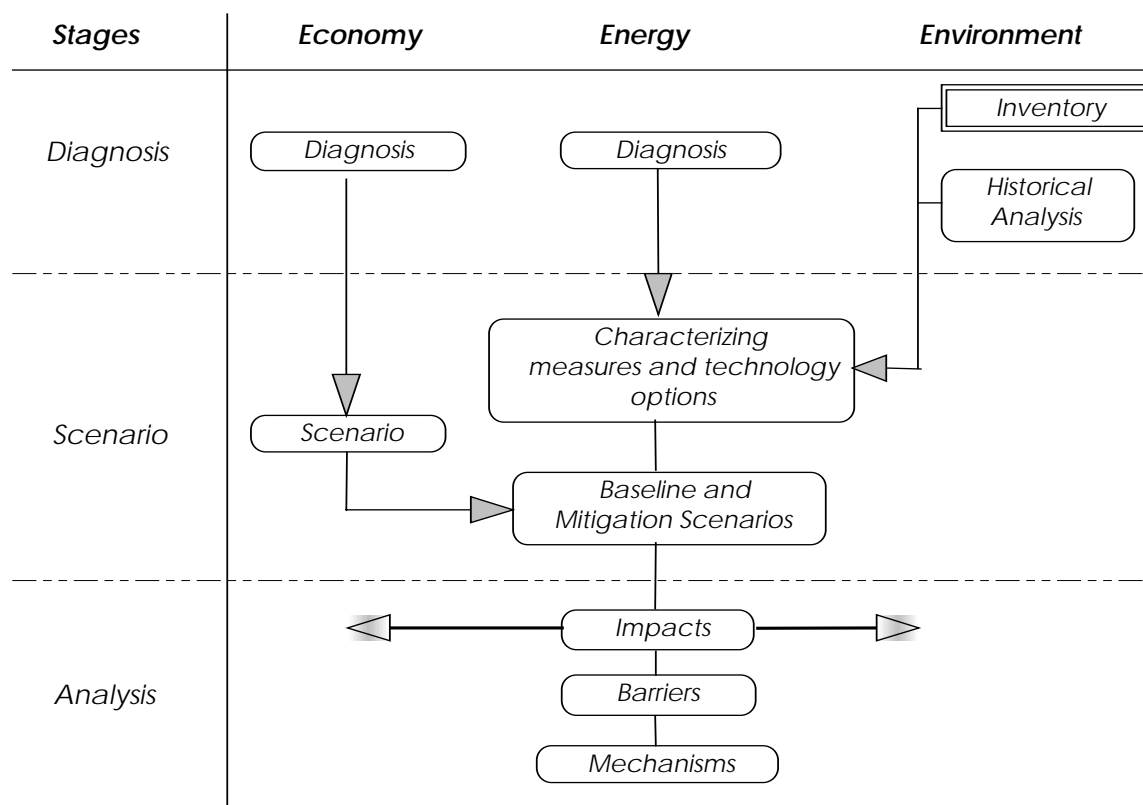
One of the issues in every *mitigation study*, which deserves specific attention in the methodological scheme proposed by the GEF, is the incremental mitigation costs curve. In very broad terms, the idea is to calculate the incremental cost per unit of GHG emission saved, listed in a growing order for growing mitigation efforts.

In spite of the extensive debate generated by this issue, precise specifications on how to calculate such curves have not been provided. Apart from the fact of whether curves should correspond to average, average incremental or marginal costs, whose calculation viability strongly relies on the type of model used, the type of costs included is yet to be defined as well as the standpoint taken to measure such costs. Actually, is reference only made to monetary costs associated to mitigation measures' adoption, or should some appreciation of the negative impacts from such measures also be included? Although the answer could be simple in terms of an ideal situation, implementation is not simple to the extent that results can be biased by the modality with which non-monetary negative impacts are appreciated.

These are critical issues in the case of Argentina where as from the economy restructuring and energy de-regulation policy assessment should address the choice of effective implementation mechanisms rather than focus only on defining the desired changes.

This type of study implies firstly to define the desired path for the energy system in the future and, secondly, to assess the expected reaction of the major players in the system to the different policy tools

3 Methodological instruments

The *baseline scenario* intends to reproduce as accurately as possible the entrepreneurial strategies under the socio-economic evolution expected for Argentina in the next 25 years, using the experience acquired since the energy deregulation. Such set of hypotheses forms the base of the scenario, regarding both the insertion in energy markets and prices, and technological choices to expand supply and the willingness to invest in such expansion.

To formulate the *mitigation scenario,* the mitigation options available for the industry, transportation and energy supply were analysed selecting those options easier to implement, but in a number enough to appreciate the mitigation potential in the country.

Based on these hypotheses, the energy system's detailed operation was analysed for both scenarios. Consistency of the energy flows from reserves to consumption were controlled using the LEAP model (Long-range Energy Alternatives Planning System) developed by the Stockholm Environment Institute -Boston Center at the Tellus Institute.

Although the LEAP model has been broadly disseminated, both in energy studies and in measuring the energy system's environmental impacts, we shall briefly describe its main characteristics[17]. LEAP is a simulation model composed by 6 modules and an environmental database used to compute environmental impacts from the energy system's expected evolution. The purpose of the 6 modules is to:

1. Analyse **demand**: a tree-type structure to calculate energy requirements, starting from end-uses and with the user-defined disaggregation level as a function of data availability. The model admits 4 elements or levels at most, ranked to characterise all energy end-uses under consideration. A typical definition for such levels is the following: *sector, subsector, use* and *appliance-source.* Depending on the disaggregation levels, the analysis can start with effectively utilised useful energy or net energy consumption. In either case, the Demand module results must correspond to the net energy to be supplied by energy source.

2. Analyse **supply** *(transformation program)*: aimed at representing energy chains and processes needed to meet energy demand. This is also a flexible structure that allows reflecting the main features of each particular system. Following flows from demand to primary energy reserves, the module permits to compute the activity level in each production process, the additional installed capacity needed to meet the demand and the foreign trade for each considered energy source. Being a simulation model, each source or process' share in the energy markets should be exogenously defined and the model converts such shares into activity levels, depending on the energy demand's expected evolution. That is, decisions are exogenous and the module is aimed at analysing their consequences, maintaining the supply-demand equilibrium in all the markets or network nodes.

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[17]   For greater detail, please see the bibliography at the end of this report.

3. *Environmental* *analysis*: an accounting framework to calculate the energy system's environmental impact, regarding both energy requirements and their supply. Such impacts result from each energy system's process activity level times the unitary impact coefficients for each process included in the LEAP Environmental Database. For the Argentine study special attention was given to record GHG emission associated to energy consumption and supply.

4. *Biomass* *analysis*: intended for energy systems where most energy requirements are met with biomass fuels, this module analyses the impacts of energy consumption on land use. As biomass fuels' share in the Argentine energy balance is negligible, such module was not used for he Argentine study.

5. *Scenario assessment*: Based on information about costs of each process in energy consumption and supply, the program economically assesses the scenario under analysis versus a reference scenario. Energy resources' economic valuation can be incorporated in this process, as well as externalities associated to each process.

6. *Results' aggregation*: This module permits aggregate at various levels the results obtained for one scenario, to formulate the reports.

The use of LEAP allowed control the consistency of scenario assumptions in two ways. Firstly, the forecasted energy balances for the whole period gives an overall insight on how the system will run in the future and clearly shows the links between energy industries. Secondly, the future evolution of the reserves/production ratio for all non-renewable primary energy sources was obtained for the whole period. As it will be seen when analysing the results of the system simulation for the *baseline scenario*, the control of this ratio was essential to assess the sustainability of this scenario's energy strategy, based on the intensive use of natural gas.

In addition, a special environmental database was developed on the basis of the emission coefficients used for the GHG emission inventory in Argentina. Linking each energy supply and consumption activity to this database, the GHG emissions computed by LEAP for 1990 and 1994 were absolutely compatible to those reported in the inventory.

The international context

1 Introduction

Within a growing globalisation, the Argentine economy will evolve strongly tied to the international context. Industrialised countries' economic growth will impact Argentine macroeconomic aggregates' evolution, both through volumes and prices in the international trade and the decisive influence on the international capital market.

Given the present opening up of the Argentine economy, equally important shall be the attitude of industrialised countries relative to climate change and their commitment to the development and use of cleaner technologies at planet-wide level.

The following sections summarise the assumptions made in each of these areas as a general framework to build scenarios for Argentina.

2 Economic context

The hypotheses adopted reflect a realistic view about foreseeable future international conditions and also attempt at providing a context for national policies in Argentina. The main issues in the analysis are:

1. the globalisation process,
2. economic blocks' formation,
3. international trade,
4. the financial context, and
5. world economy growth rate.

2.1 The globalisation process

The globalisation process will call for further adjustments in central economies, especially in Europe. After the adjustments implemented since the beginning of the '80s a slow albeit sustained growth stage is expected in the long term. Resistances are however expected vis-à-vis the adjustment, which might lead to distinctive changes of course. However, such cycles are not expected to result in a drop in the per capita GDP in industrialised countries.

Blocks will not adopt homogeneous behaviours in the short or long term. In Europe adjustments will be the most difficult due to the institutional weight of previous production methodologies, partially affecting the growth trend until 2000/2005. It is however believed that there will be a necessary retreat towards more integrated and partially protected economic areas, while important changes will take place as regards labour and consumption patterns. In such sense a reduction is expected in working hours and an increase in leisure time resulting in greater consumption diversity.

The technological leadership regarding environmental impact control shall be conflicting, although Europe will be in the lead. This will allow for an increase in value added to

production, which would be controlled and captured in the commercial circuit by corporations instead of the State.

The high living standard achieved by most of the population in developed countries, and the trend of new generations to adopt more moderate consumption patterns, would limit industrialised economies' growth rate.

Production's geographic migration to less developed countries, driven by globalisation, will not necessarily imply recession in central economies due to the development of other activities in the service-area and the existence of positive financial flows and technology control resulting from corporations' ownership structure. However, unemployment may lead to important changes in consumption and labour styles affecting other regions of the world.

2.2   Economic blocks formation

Economic blocks' formation will facilitate not only more international competition and trade but also a certain natural protection within each block, as well as strategic alliances among them. Still, this process might not be as fast as expected and free from conflicts, especially because international restructuring in open economies driven by corporations' interests gives way to winners and losers.

Towards the year 2005 the world may be relaying again on more territorialised economies, even when the scope of protectionism shall not match previous levels. It is assumed that, rather than a return to the closed schemes of the first two post-war decades, the system will tend to progressive protectionism once global restructuring is completed. Protectionism could be instrumented through different types of restrictions (environmental, social, and others) and at least one decade would be required to complete the process unless conflicts became rapidly acute.

Although the scheme aims at greater worldwide productivity, during the repositioning stage the process will necessary involve a strengthening of income and property concentration. Such movement generates, on one hand, incentives to investment as the economy is more profitable, but at the same time poses obstacles to growth because of demand concentration and sectoral restructuring. This necessarily implies slow growth where the absence of conflicts is only the exception.

2.3   International trade

Industrialised countries shall gradually eliminate subsidies and tariff barriers that affect certain primary products from developing countries (DCs), especially from Latin America. Such attitude will be enhanced by DCs' greater opening to products and services from central countries and by the access of transnational capitals to the ownership of natural resources in DCs with agricultural and/or mining potential.

However, the greater potential for agricultural products' trade will derive from worldwide economic growth, especially from living standard improvement in Asian countries, as it is hard to consider an acute regression in the Mediterranean area's role as agricultural products supplier to the European market.

The trend will no doubt move towards greater specialisation, thus giving rise to more integrated productive chains within the regions that offer true competitive advantages.

Better living standards in the rapidly industrialising countries will increase their consumption levels furthering primary products and foodstuff's international trade.

However, the benefit each country will draw from such situation shall depend on its articulation in the marketing scheme and on the surplus percentage captured for reinvestment within its territory. The lack of harmonious policies might deter the potential growth rate. Social exclusion shall be the big challenge of the open model and the reconfiguration of power structures at international scale shall prevent the return to previous economic models.

In any way, regional blocks' economic growth shall basically depend on the opening of industrialised countries' markets to products from Asian and Latin American countries. Presently, Asian exports account for 21.4% of USA imports and only 6% in the case of the European Union (EU). Latin America's export share is much lower, 12.9% and 2.44%, respectively.

In turn such exports represent 12.3% of Asian countries' GDP and 7.3% for Latin America. However their impact on developed countries' economy is practically negligible: 1.6% and 0.9% respectively of the USA GDP and 1.2% and 0.5% respectively for the EU. As noted, the European market appears more closed than that of the USA.

To date Latin America has specialised in the supply of primary and energy products to the USA, while Asian countries export mainly manufactured goods, machines and equipment, especially manufactured consumer goods. Apart from the desirability of such an occurrence, if the trend towards globalisation deepens it should go together with greater regional specialisation and a greater opening of industrialised countries' markets, especially for Latin American products, which would permit a larger relative growth of Latin American economies.

2.4   The financial context

The international financial market is supposed to acquire greater stability resulting in better funding conditions for terms and rates. Such situation would result from investments' high profitability and the relative squeeze of the international capital demand caused by a slow global economic growth, and by new financial mechanisms linked to captive markets. However, the growth in number of emerging markets and the difficulties to honour their debts could eventually caused a turbulent financial climate, especially in fragile Latin American, Asian and African economies.

Therefore, although a global context of liquidity and low interest rates is to be expected, periodic and focused fluctuations should not be ruled out. This would mean differential interest rates according to the risk posed by countries.

Regarding payment terms for the existing foreign debt, financial agencies might feel more inclined to support those governments that exhibit caution and political continuity, bearing in mind the fragility of economies that have undertaken deep reforms as part of their foreign debt re-negotiation. In any way, unrestricted financial support should not be expected, even if additional funding exists to prevent financial catastrophes.

Although such perspective may hinder the rapid growth of debtor countries' domestic market, the financial constraints could be offset by central countries' interest (international financial agencies' principals) in keeping such markets for their exports, and by the repatriation of capitals that fled the DCs to industrialised countries during the '80s.

As for capital flow for productive investment, in Latin America foreign investment is expected to focus on natural resources, with a degree of local transformation

dependent on each country's competitiveness. In the specific case of Argentina, growing foreign interest will exist for agroindustries, considering the complex commercial circuits generated by globalisation, although investments in mining and infrastructure to facilitate a better integration between blocks should be expected (bioceanic lanes).

Closer economic relations between Europe and the Mercosur are not ruled out as an alternative to competition from USA and Asian countries, resulting in higher investments in this area of Latin America.

2.5 World economy growth rate

When comparing the average world-wide and regional economic growth rates during the second half of the century with those recorded since the eighties, a deceleration of the economic growth becomes evident, with the exception of Asia due to the remarkable growth of Southeast Asian countries and China. Based on regional profiles and the above-mentioned considerations, the economic growth rates per region illustrated in Table 5 have been adopted. It is noted that the projection implies a long-term global growth not higher than the one recorded in the 1977/1993 period although with strong regional differences.

Table 5   Long-term economic growth hypothesis (%)

REGION	1993 GDP	% of world-wide GDP	1967/1993 Rates		1995/2030 Rates		
			1967/ 1976	1977/ 1993	1995/ 2005	2005/ 2030	1995/ 2030
Africa	252.2	1.1	4.8	2.1	3.0	2.2	2.4
Asia (DCs)	1605.1	7.0	5.2	7.3	6.5	5.6	5.9
Eastern Europe	848.4	3.7	6.0	3.7	4.3	3.7	3.9
Middle East	642.0	2.8	9.0	2.3	2.5	3.2	3.0
Latin America	1352.9	5.9	5.9	2.5	3.8	3.9	3.9
Japan	4287.9	18.7	5.1	3.6	2.5	1.9	2.1
Europe	7085.4	30.9	3.8	2.0	2.5	2.0	2.1
USA+Canada	6856.1	29.9	2.8	2.9	2.5	2.2	2.3
TOTAL	22930.0	100.0	4.4	3.0	3.0	2.8	2.8

Source: In-house elaboration on the basis of IMF and UNDP historic data

A different regional economic growth rate was assumed in the first decade relative to the next 25 years, as economies are expected to be strongly affected by the international economic restructuring in what has been called globalisation, post-Fordism or the end of massive production integration in national territories.

In such sense, the developing Asian countries, Japan and USA are expected to have lower economic growth rates than in the 1977/1993 period, whereas Latin America and Europe shall improve their economic growth. The worldwide average growth rate is expected to remain around 3% annually.

As of the year 2005, the economic dynamics in USA + Canada, Europe, Japan and the developing Asian counties will probably be tempered, although the latter will still have very high growth rates when compared to the world-wide average. On the contrary, Latin America would evidence renewed dynamism with 3.9% annual rate. Middle East countries are also expected to grow faster than in the coming years and also Africa will improve its past economic performance even when the higher economic growth would

not suffice to increase substantially the per capita GDP, as seen in Table 6. The worldwide average rate will be close to 3% annually.

Table 6   Economic forecasts - year 2030

REGION	% of world-wide GDP	1995/2030 Rates (%)	
		per cap. GDP	Population
Africa	1.0	0.1	2.3
Asia (DCs)	19.2	3.9	1.9
Eastern Europe	5.2	3.4	0.5
Middle East	2.9	0.9	2.1
Latin America	8.3	2.1	1.7
Japan	14.3	1.7	0.4
Europe	24.3	1.6	0.5
USA+Canada	24.7	1.3	1.0
TOTAL	100.0	1.4	1.4

Source: In-house elaboration on the basis of IMF and UNDP historic data

As seen in Table 6, industrialised countries would increase the per capita GDP at 1.6% or 1.7% average annual rate for Europe and Japan, and 1.3% for USA and Canada. A rapid growth of the per capita GDP is expected in developing Asian countries (3.9%) and Eastern Europe (3.4%), and somewhat more moderated for Latin America and the Caribbean (2.1%). It was assumed that the economic growth in Africa and the Middle East would be much slower because development and modernisation policies in these regions have been more conflictive due to cultural reasons difficult to revert in the medium term.

Assumptions about variations in world-wide GDP's regional share, shown Table 6, reflect international trade's expected evolution as a function of the changes witnessed since the mid-'80s, especially in developed countries imports' structure (USA and European Union).

3 Technological context

Future technological development is a part of the international framework in which developing countries (DCs) shall perform, without any possibility whatsoever of impacting technology markets, although DCs can in turn be affected by such markets' behaviour. As "technology takers", DCs will only differentiate from each other by the facilities or obstacles they impose to the penetration of new energy and goods and services production technologies, as a function of their strategies to become a part of international markets. From such standpoint technological development in the national baseline and mitigation scenarios shall differ only through active national policies to favour the penetration of "cleaner" technologies.

What is still to be determined is whether the development and international supply of technology will be noticeably affected by industrialised countries' attitude regarding climate change mitigation. That is, are important technology changes expected to take place in the mitigation scenario relative to the baseline scenario in the medium or long-term?

The answer is not simple. In order to analyse in greater detail the technological dynamics in general and the specific situation of Argentina in this respect, as part of the project a workshop was held on "The technological innovation in the use of

energy", on June 11 and 12 in Buenos Aires. During the event debates were organised in 6 round tables to discuss the following topics:

1. *The new technological context*, to discuss the impact of technological innovation on economic organisation methods and on the long-term urban development, with the participation of well known researchers in the economic and urban fields, and in the development of new materials.

2. *Technologies for transportation: means and modes of transportation*, to analyse general trends in the use of different transportation means and modes in Argentina, with the attendance of transport planning experts and road vehicle suppliers.

3. *Transportation technologies: new energy sources in transportation*, to analyse state of the art in technologies aimed at substituting motor fuels in transportation, with the attendance of experts representing research centres and companies working on the issue.

4. *Technologies in the industry*, to analyse the technological level attained and innovation perspectives in the major Argentine industries (steel and iron, petrochemical and food products), with the participation of economists and major companies' representatives.

5. *Technologies in electricity supply*, to analyse progress expected in the different technologies for electricity generation and transmission, with the attendance of international equipment suppliers and researchers in the field of nuclear and solar energy and superconductivity.

6. *Technologies in the hydrocarbon industry*, to analyse the trends in the exploration and production of hydrocarbons and petroleum products, attended by the most important companies operating in each area.

The results of the workshop were extremely useful both to clarify international efforts in the development and launching of new technologies and to envision the Argentine position with regard to their use in the country.

Leaving aside the local impact of technological transformation, which shall be further discussed when talking about the baseline and mitigation scenarios for Argentina, experts' general opinion was that the international research and launching of new technologies evidences a fast development and is fuelled by economic factors and environmental considerations.

As for the economic aspect, globalisation process involves the search of higher competitiveness through production costs' reduction. Such search favours the adoption of more efficient technologies in the use of energy, which are mandatory for those who wish to maintain or increase their standing in international markets.

Although new technologies permit to achieve high productive efficiency with smaller production scales, the trend is towards product diversification rather than to lessen the size of companies, thus reducing the impact of advertising expenditures on production costs.

The development of new materials, especially those derived from the petrochemical industry, is a challenge for the production of traditional basic goods (steel, glass, ceramics), which have to resort to new products and production processes to retain their market competitiveness.

Growing international concern about environmental problems also favours the adoption of more efficient technologies, in the use of both energy and inputs in general. Such environmental concern goes beyond the climate change issue and acts to further the adoption of actions to mitigate GHG emissions.

On the basis of such considerations, it has been assumed that internationally available technologies in the next 30 years shall not be noticeably affected by the position adopted by industrialised countries' governments regarding climate change. Therefore, no significant differences shall exist between the international technological context in the baseline and mitigation scenarios. Differences will only exist regarding local dissemination levels, depending on the climate change mitigation policies adopted by each country.

In late years several voices have been raised to call attention on the alarming reduction in funds for basic scientific research and such behaviour's deleterious effects on the future of technological innovation. Although governments do face growing difficulties to fund their scientific systems (even in industrialised countries) and companies are reluctant to pay for such a vital activity in their future development, the effects of such context would be felt in the very long term, which goes beyond this study's horizon year.

The movement required for the launching of technologies based on present scientific-technical knowledge is expected to be fuelled by both public and private funds. However, it seems difficult to expect absolutely new technologies to emerge within such context.

4 Energy-environmental context

International energy markets' perspectives will strongly rely on the international behaviour vis-à-vis the environmental problems. It seems therefore highly convenient to make some comments on the most likely international context in this respect.

The international community is very rapidly becoming aware of the environment's fragility and the dangers involved in its ongoing degradation. However, effective environmental protection involves very deep changes in current consumption patterns and economic organisation, difficult to implement in the present politic and economic context. A proof of that is the clear difficulty to reach a consensus on government commitments to reduce GHG emission.

In spite of uncertainty about GHG reduction percentages and the terms to be finally agreed to achieve such goals, Developing Countries (DCs) are expected to be highly affected by such process. Regardless of the local commitments undertaken by industrialised countries, DCs shall be pressed to contribute to climate change mitigation. In such sense, restrictions on their products might be imposed in industrialised countries' and financial markets on the basis of environmental considerations. Only DCs' effective organisation to defend their interest could relieve such pressures, which could become difficult in the present economic globalisation context.

To develop climate change mitigation studies for DCs one should wonder whether the international environmental context in the baseline and mitigation scenarios should be different. Or whether the decision to reduce GHG emissions has already been made and only the size of the efforts devoted and the places (countries) where actions should be taken are to be defined. In the specific case of Argentina it has been considered

important to incorporate such environmental pressure in the building of both scenarios, regarding economic perspectives and technological renewal.

Regarding the expected evolution of international energy markets and although the declining role of oil in primary energy supply, its price still rules the price of energy, given its relative importance with respect to primary energy sources, its nature of tradable goods and of a fuel substituting for other sources.

Expectations on future oil prices may differ depending on the hypotheses and scenarios designed. It is clear that economic rationale has not been the major element involved in its pricing, as evidenced by its evolution in the last 25 years. Unpredictable political factors have had a significant impact on crude prices' volatility and it is not clear whether the behaviour of predominant agents in the oil business were cause or consequence of the price level.

However, crude's present international market involves a greater number of players, supply being more diversified than in the past. The influence of each agent is not the same as in the past, both regarding suppliers and purchasers. On the other hand, financial speculation and future prices in the oil market introduce additional elements to distort markets' operation.

Also, significant influence is exerted by technological progress, the expected international attitude with regard to environmental issues, especially those related to climate change, and the proposed mitigation actions or options (carbon tax, energy tax).

Although the purpose of this project is not to define a future scenario of crude international prices, it is deemed necessary to establish certain possible hypotheses and define a price trend in line with such hypotheses. The assumptions adopted in such respect are the following:

1. loss of power by OPEC

2. Russia's difficulty to increase and even maintain its production level

3. Mexico's position shall approach that of the OECD

4. Great Britain and Norway shall further increase their supply in spite of the price drop and their limited reserves

5. China is on its way to becoming a strong importer

6. U.S.A. shall increase its oil imports, vis-à-vis the drop in domestic production and consumption increase

7. The E.U. shall import about 55% of its needs

In such context, crude oil prices are expected to remain almost stable with a slightly upward trend, especially after 2010. The international crude oil prices' expected evolution appear in the Table 7, presenting the WTI prices expected for crude oil in the New York market, taken as reference in Argentina for domestic pricing purposes.

The factors that could contribute to the fulfilment of the expected price evolution are discussed below.

Some co-ordination between the various players (OECD, OPEC, multinational oil companies, banks and the major non-OPEC exporters) should be necessary. Such co-ordination should guaranty prices highly enough to ensure both the investments required

to increase production capacity (including the search of new reserves), improving the technology to decrease costs and permitting also to promote rational use of energy.

Table 7   Evolution of international crude oil prices

Year	USA WTI crude oil US$/barrel
1996	22.10
2005	24.00
2010	25.50
2020	29.75

Another major element is to eliminate financial speculation through oil shares in stock exchanges that has proven to be a major cause of price instability.

The search of a co-operation and co-ordination mechanism between players, which permits to attain a new order in the oil market without leaving aside market forces. Such co-operation could include more frequent partnership between State and private oil companies, among other aspects.

Such crude oil prices served as reference to define the expected evolution of petroleum products and natural gas domestic prices, as discussed in Chapter VI, Section 1. In the specific case of natural gas local supply and consumption conditions were also taken into consideration.

Expected evolution of Argentine economy

1 Introduction

This chapter contains the general outlines of the long term socio-economic scenario for Argentina, based on the socio-economic diagnosis and on the assumptions made on the future global and national economic context, through the year 2030. The purpose of the socio-economic scenario is to estimate energy consumption and supply according to the designed future energy policies and then analyse the impact of active policies to mitigate the GHG (greenhouse gases) emission. The macroeconomic projections resulting from the scenario are for five-year periods until the year 2010 and for ten-year periods through the year 2030.

While the short and medium-term evolution shall be greatly conditioned by the current situation described in the diagnosis, the long term reflects mostly the assumptions made on the global economic prospects and other variables having a high degree of uncertainty difficult to be reduced.

In fact, such as has been stated, the main difficulty encountered in predicting the long term evolution of development lies in the absence of knowledge about the dynamic links between technological options and consumption patterns and about their interaction with long term policies and economic trends. Further difficulty is created by more generic uncertainties about political, social factors and others which are in turn related to important issues such as intentionally, power, trust, credibility, social organisation, etc. [18]

In this context it should be stressed that studies on the mitigation costs made to date, particularly in developing countries, seem to indicate that the most significant differences in the result do not originate so much in the type of model used for the projections (E.g. "top-down" vs. "bottom-up" models), as in the fact that the development of baseline or reference scenarios for developing countries is very complex and subject to a high degree of uncertainty [19].

The basic elements for the elaboration of a scenario involve diverse aspects, all of them being closely interrelated. We shall only refer to a few that appear decisive for the subject under review, namely:

How to deal with the assumptions relative to the long term evolution of life styles[20] in the developed countries and their repercussion on the economies of developing countries?

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[18]   Cf. Hourcade J.Ch. and Robinson J., Mitigating Factors: Assessing the Costs of Reducing GHG Emissions, in Energy Policy Vol. 24, No. 10/11, October/November 1996, p. 870.

[19]   Cf. Halsnaes K., The economics of Climate Change Mitigation in Developing Countries, in Energy Policy, op. cit. p. 926.

[20] For a deeper analysis of this subject see, Lee Schipper, Energy Efficiency and Human Activity: The importance of Lifestyles, New York, October 1993. See also, Alan Warde, Consumers, Consumption and Post-Fordism, in Roger Burrows and Brian Loader, Towards a Post-Fordist Welfare State?, Routledge, 1994.

How to obtain a reasonable net result of contradicting trends without this merely expressing the expectation of the scenario maker? How to envisage the multiple and long term effects of worldwide economic restructuring and those of increased productivity at microeconomic level? Shall work patterns be subject to permanent modifications tending to further flexibilisation and income reduction or will tend to reduce working hours? Shall trends be evident in all sectors or only in some? What effects shall the greater availability of free time have on global consumption and on energy consumption in particular? Will it be possible for one part of the world to move into this direction without this "culturally" affecting productivity in other parts of the world? What type of technological advances shall be evaluated and how will this be achieved? Is it possible to identify a priori the technological impact on society in the next 30/35 years without information of the main projects awaiting execution worldwide? How to deal with the interdependence of technological projects and their impact without oversimplifying the problem? Shall the evolution of the relational model put an end to traditional politics and formal democracy such as some authors envisage? [21] Shall extreme urban concentration in the megalopolis and the need to expand "urban markets" cause a greater decentralisation of production or shall it simply tend to increase the complexity of the physical, technical, economic, political and social relations?

Even though making scenarios does not imply forecasting, it is obvious that for the sake of global consistency it is necessary to think of the nature and trends of all dynamic connections. It is also necessary to define a priori the evolution and net results of contradictory trends which cannot be easily modelled other than in a very generic way, even if an integrated global model representing identified and proven links in a suitable manner were available.

Even with such limitations, an attempt has been made to depict a scenario contemplating the future linking of events so that the evolution of the different variables may follow the logic of the productive system in a society organised according to current conditions. The assumptions made and the expected evolutions have been broadly developed.

The aspects dealt with in this chapter are the following: 1) Hypotheses about the regional and sub-regional context; 2) Hypotheses about the national context, 3) Basic projections.

While the two first above-mentioned items require consideration of all factors that are relevant for the construction of any socio-economic scenario, the third must also contain scenario-specific elements. This means that data must be sufficient for the necessary macroeconomic projections to estimate future energy consumption.

The sectoral design of the scenario attempts to capture and make the links economy-energy- environment clear enough to provide an "outside" perspective relative to the projection model for assessing the degree of consistency achieved and controlling the validity of the subjective elements in the construction of the different hypothesis.

In this case we have subdivided the projection of the Argentine macroeconomic variables into two periods.

Until year 2005, the macroeconomic behaviour is based upon a detailed analysis of the productive branches. Particularly, the export potential of the agricultural, mining and industrial sectors and the restrictions resulting from the production channelled to the domestic market. It has been assumed that the macroeconomic restrictions identified in

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[21]   Cf. J.M. Guehenno, El Fin de las Democracias, Ed. Paidos, 1997.

the Diagnosis Report[22] shall have a stronger impact in the first quinquennium and part of the second. In this way, sectoral growth shall be the result of complex and antagonistic forces; on one end the dynamisation of production by exportation and growing markets and on the other, the weight of global adjustment, which is to impose strong restrictions on domestic consumption.

This analysis has been done for the agricultural sector on the basis of forecasted productivity, cultivated area and destination of production for the main agricultural products, assuming that the limitation is not on the demand but on the supply side, at least for the short and medium term. The maximum growth capacity is considered and it is assumed that the foreign market is to absorb the resulting production, which in Argentina has competitive advantages.

In the case of the mining sector it has been attempted to reflect the possible evolution in accordance with existing projects. For industries, the analysis results from the projection of activity indexes by branch at the 3-digit level of the ISIC Rev.2, crossing global indexes and industrial product statistics. Separate projections for domestic and foreign markets in each manufacturing branch were made on the basis of the scenario hypotheses describe in detail in the following sections.

The growth of the transport, communication and energy sectors is basically linked to the secondary and tertiary sectors and the latter are in turn related to the productive branches and the public sector. Global growth results from sectoral growth and it is in turn matched with parameters such as capital/product, saving/investment ratios and domestic and external deficit. For the post-2005 period, assumptions are of a more aggregate nature and provide the sectoral environment defined by most generic assumptions about the long term international and regional levels.

2 General hypotheses on the regional and sub-regional scenario

This point refers to the assumptions on the future inter and intra-block trade. Given the trends described in Chapter III, the starting point is that the growth of regional blocks shall be determined mainly by a greater opening of the North developed markets to Asian and Latin American products, more to the latter than to the former in relative terms. It should be noted that this process would intensify towards the middle of the coming century.

Taking these data into account and on the basis of the analysis of the regional perspectives, the hypotheses for the region and the sub-region are the following:

1. The agreements signed in the Mercosur shall contribute to stabilise national economies and lead to more co-ordinated solutions among countries. Also, stability shall be the key factor for the success of Mercosur.

2. The integration process shall not only increase intra-regional trade but also give rise to a higher degree of sectoral complementation. This in turn shall lead to increase quality of products, lower production costs and improve competitiveness of the region relative to other trade blocks, particularly with respect to Asian countries.

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[22] Cf. Secretaría de Ciencia y Técnica, Project ARG/95/631, Estudio de Mitigación de GEI, Informe Parcial Nº 2, La Economía Argentina, Evolución y Situación Actual, IDEE, January 1997.

3. Trade shall increase all through Latin America, as the result of the globalisation dynamics and of the progressive awareness of the contingent and permanent business opportunities the region shall offer. This will be facilitated by the reduced size of present markets that may become very dynamic.

4. Although a greater specialisation of activities shall take place as a consequence of globalisation and economic integration, it shall not be extreme. In any case Argentina shall be mainly oriented to agroindustries and mining, comprising a broad range of activities having up and down-stream impacts. This process shall be led by transnational companies and large national groups associated to the former. Brazil shall follow a similar trend.

5. As a result of environmental legislation world-wide, many polluting industrial and mining activities shall be settled in LA&C. In Argentina, investment in agroindustries, mining and complementary activities —many of which produce a substantial environmental impact— shall be significant.

6. Growing Asian countries shall become consumers of raw materials, food and agroindustrial products from LA&C.

7. The rapid growth of exportations shall permit to put an end to the growing level of foreign debt in the region although a high level of international flexibility shall be necessary. Otherwise, economies shall become stagnant producing a negative effect on income distribution.

3 General hypothesis with reference to the national level

This point specifies the background conditions that determine the macroeconomic projections, translating the main assumptions for the global, regional and sub-regional level to the national situation in the context defined by the economic patterns adopted by Argentina at the beginning of the decade already described in the diagnosis. As has been said in the introduction, the restrictions existing in the present environment shall be felt more strongly in the first decade than later on.

3.1 The starting-point. Restructuring of production towards a more deregulated and open model

The transition towards what Katz (1996) calls "the starting point of a more deregulated and open model" has not been neutral[23]. The most negatively affected branches were the following: textile, garment, leather, and the metal-mechanic (producer of capital goods, machines and tools, agricultural equipment, machines for the food industry).

The opening process affected two central nuclei of the productive structure, one intensive in unskilled labour (creating higher unemployment rates) and the other engineering intensive. Discrimination was also felt in terms of company size (small and medium sized) and region of the country.

On the contrary, some sectors reorganised to almost reach international productivity levels (in vegetable oils, labour productivity increased tenfold), although in the context of a strong increase in property concentration.

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[23] Katz J.M., Estabilización macroeconómica, reforma estructural y comportamiento industrial: estructura y funcionamiento del sector manufacturero latinoamericano en los años '90. Buenos Aires, Alianza, 1996.

Thus, this process has deepened structural differences; one portion of the national productive structure is close to international productivity levels, whereas most of the local productive branches are far from it.

Reorganisation approaches can be classified into two types: the "offensive" strategies (based on strong productivity increases originated in changes in production process and strong investment on equipment) and the "defensive" strategies (based on productivity increases through laying off but maintaining small production scales).

However, the "defensive" strategy loses effectiveness in time and it eventually becomes necessary to adopt "offensive" strategies through investment leading to structural changes in the production function.

Growing specialisation is seen towards the processing of natural resources, be it traditional commodities or industrial commodities (vegetable oils, steel, petrochemical products, natural gas, fish flour, etc). These activities have undergone a deep restructuring of the manufacturing facilities to reach international efficiency levels but with substantially smaller production scales. Also, a growing trend is observed to selling products produced by third parties, and to producing with imported inputs, thus breaking the traditional 100% national integration, which characterised some industries.

In this way, the metal-mechanic branch (the pivot for industrial development in the stage of import substitution) has lost share, with the only exception of the automobile branch. The latter is the only activity that has not followed the opening trend and has received preferential treatment, making advantage of the globalisation of the industry and of the role that local subsidiaries play in this process.

Current specialisation is moving in the direction of processing of natural resources (typically industrial commodities), switching from activities featured by intensive product-engineering and production planning to intensive process-engineering industries (vegetable oil) characterised by absolutely homogeneous products (commodities).

There seems to be no chance in the engineering-intensive sectors, whereas research and development costs are out of reach even for those local companies using up-to-date production technologies. For example, in the pharmaceutical industry, it is estimated that R&D expenditure in industrialised countries, is in the range of 1,500 million dollars a year, when in the best of cases, total sales of a large Latin American pharmaceutical company may amount to 800 million dollars.

The targeting to natural resources in developing countries economic restructuring (and the direct foreign investment involved in this process) is further reinforced by the fact that regulation, property regimes and controls on the use and preservation of natural resources in host countries are extremely poor in comparison with international regulations.

The main niches for Argentine industry to develop in highly competitive conditions seem to be the food industry and the agricultural sector (both in the phase of agricultural production and in the industrialisation phase), basically by searching opportunities to sell higher quality and value added food products (i.e. dairy products). This situation partially explains the inflow of foreign capital to be invested in the food industry.

Regarding the exporting profile, the most important items shall be related to the exploitation of gas, minerals, fuels and commodities, generally of low value added. It is estimated that through the gas pipelines to San Paulo and Santiago de Chile, Argentina shall export four thousand million dollars worth of gas in five years. Soy oil, in the light of

the expected opening of the Chinese market, and mining —where a substantial flow of foreign investment is expected— appear to be promising. Some estimates suggest that in the course of ten years Argentina may export ten million dollars of mining products (including fuels).

One of the big challenges for the industry in Argentina will be to develop the ability to switch a very low value-added-products exporting profile (very close to pure commodities) into some specialised industrial products, avoiding the industrial property blockades that traditionally appear when a country moves from commodities to speciality. The path from commodities to specialisation implies an innovative system accompanying the process.

Thus, since the basic science component plays a decisive role in this process, a pre-requisite for the transition is scientific innovation.

Beyond individual survival efforts by companies, international experience shows the need to implement systemic competitiveness including a suitable physical infrastructure, design and maintenance of a scientific-technological policy and the creation of a network of suppliers and subcontractors.

As for the impact of restructuring on each type of companies and the potential evolution, the following comments should be made:

- During the industrial restructuring in Argentina, the public companies (PCs) and the small and medium-sized enterprises (SMEs) have suffered the strongest impact, whereas the multinational companies (MCs) and the big economic groups (BEGs) were benefited by the changes in the rules of the game.

- In terms of physical productivity of the production factors, the performance of some BEGs is similar to the international values although the same does not apply to production scale.

- Neither MCs nor the BEGs undertake technological efforts in terms of the local development of new processes and products but are instead limited to adapt and optimise the imported technology.

- The sectors that achieved a better relative position as a result of restructuring were those in which BEGs played a preponderant role and MCs only followed the growth in these sectors, generally in association with the former. However, MCs are at present recovering share in the Argentine industry, mainly in the food and automobile sectors, with greater import and export rates than during the import substitution stage.

- During the economic restructuring process, SMEs suffered a remarkable loss in their relative position. Thus, integration to international markets, mainly to the Mercosur, shall be determinant for their future. However, this sector has no access to many of the advantages of the expanded markets.

Thus, adaptation to the international scale can lead to the reorganisation of products and processes to achieve larger production scales and to different patterns of association with other companies (SMEs or not). In this context, the most likely scenario is a process characterised by the disappearance of many companies, the restructuring of others and the advent of new companies.

3.2 General hypotheses

While the most specific hypotheses shall be described in the following section jointly with the forecasted values for the main macroeconomic variables, the general hypotheses are the following:

1. The opening up the economy within Mercosur and also with other areas through the regional block shall deepen. This shall be beneficial for the long-term growth of Argentina and Brazil;

2. Selectivity of imports shall be encouraged to facilitate production re-conversion and avoid lavish consumption. Credit policy shall be aimed at this goal, even when the poor distribution of income may counteract this process;

3. Agricultural and agroindustrial exports shall have a rapid and sustained growth, owing to the Brazilian demand as well as to the better access to the European and Asian markets (directly or through the U.S.). The agroindustrial complex shall gain growing importance, mainly in the dairy, fish flour, vegetable oil and fine wines industries;

4. Industrial exports (other than agroindustries) shall continue to diversify but growth shall be slower, with the exception of industrial commodities (steel, petrochemical and aluminium) and the automobile sector (owing to the integration with Brazil), whose growth can be substantial. However, mining exportations shall grow dramatically (including fuels);

5. If convertibility is not maintained in the short term, a progressive and agreed solution shall be sought. Hyperinflation or chronic inflation processes like in the '80 shall not occur, with the exception of specific events resulting from adjustment to medium term policy changes. Problems originated in the high level of foreign indebtedness shall be attenuated by the flexible attitude of the international banks and then progressively overcome by the strong increase of exportations. However, since macroeconomic balances shall for some time continue to depend on very volatile variables, some concerns exist on the future economic evolution of the country. The main question refer to what will happen if collection fails to increase when the privatisation process is over?; how will an increase in real international interest rates impact, given the high level of foreign indebtedness?; how shall new investments on infrastructure be financed?; and what will happen to sectors requiring a higher level of state intervention? [24];

6. Tax collection will continue to improve. Provinces and Municipalities will also increased their collection from unpaid taxes and rates. To that end some indirect coercive mechanisms will be used (re-registration, mandatory contracts updating and so on)

7. Current public expenditure will increase at most at population rate, at least until year 2005. A faster increase can only be expected after that year, but it will remain constrained also in the long term.

8. Income distribution shall be more regressive and most particularly, the public/private sector ratio shall be modified. This will help increase savings and restrict consumption, which is necessary to achieve both growing exports

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[24] Fanelli, J.M. and Frenkel R., Estabilidad y Estructura: Interacciones en el Crecimiento Económico, en Katz J.M., 1996, op. cit.

compatible with local supply and keep imports under control in an opening economic environment (like the current one or at most slightly higher);

9. After the repatriation of the national capital abroad, no new, massive currency flights are foreseen. Domestic savings shall be transformed into credit capacity and in mutual funds compatible with the global industrial re-conversion;

10. Big economic groups (transnational or not) shall reinvest a substantial portion of their surplus in the reorganised sectors with a view to intra-regional and trans-regional exportation. Groups shall continue to invest on Infrastructure and Related Services and also on land, industries and mining-related activities;

11. Until year 2010, the greatest dynamism shall be generated by exportations. Then, higher stability and higher income levels shall create the conditions to improve domestic consumption, which, along with exportations, shall drive the economy;

12. Unemployment shall be reduced very slowly by several reasons: 1) slow economic recovery after the 1995 crisis; 2) the risk of "overheating" the economy in the midst of macroeconomic constraints (particularly trade and public accounts unbalances), 3) the productivity growth derived from both the crisis itself and technology innovation. It is assumed that these conditions shall relax after the first two quinquenniums;

13. The modernisation of some services and the industrial reconversion shall lead to the progressive modernisation of the entire industrial sector, particularly in connection with exports within the Mercosur and to other regions;

14. In spite of the dissatisfaction with official policies, the absence of better alternatives and the decreasing degree of participation shall provide the necessary conditions for the labour/social conflicts to be manageable and compatible with the global stability required notwithstanding periodical crisis;

15. As the business opportunities related to the privatisation process extinguish, investment may be oriented to technological innovation. As far as investing in the privatisation of utilities has the lowest risks, privatisations may force a crowding-out of other more risky investments that appear more uncertain in terms of profitability (typically those implying the greatest technological innovation), which involve resorting high discount rates to provide protection against any contingency.

It should be noted that these hypotheses not necessarily imply a judgement about the likeliness or desirability thereof. The same is only the necessary environment for the projections of the socio-economic scenario to be relatively consistent and realistic, particularly for the middle term. In the long term they reflect the assumptions adopted for the global context.

4 Long term macroeconomic projections for the Argentine economy

This part of the analysis comprises the description of the expected global and sectoral economic growth in Argentina and the study of the consistency conditions of the basic projections. At the same time the analysis is done by quinquenniums until year 2010 and then by decades until year 2030.

4.1 The evolution of macroeconomic and demographic variables through the year 2005

4.1.1 Evolution of the total population

Official studies estimate that the total population will grow during the next decade at a rate of 1.34%. In this way the total population estimated at 34.7 million in 1995 shall reach 39.7 million by the year 2005.

Given that 88.4% of the population already lived in cities of over 2000 inhabitants in 1995, it has been estimated that the urbanisation rate shall be in the range of 90.8% in 2005.

The size of households is to remain constant at about 3.8 dwellers per household. This reflects the net result of contradictory trends between the population sectors having modern standards and sectors having traditional standards, which are coincident with the lower income groups. The latter have grown in the last few decades in relative terms as a result of the uneven distribution of income.

4.1.2 Total supply and demand evolution

Macroeconomic projections are based on assumptions on the evolution of exportations and consumption, considering both the potential demand and the sectoral supply capacity and their future evolution.

Growth rates are 3.3% from 1995 to 2000 but only 1.9% with respect to that of 1994, taking into account that GDP drop in 1995 was above 4%.

The drop in consumption during 1995 was estimated in 7% relative to 1994 values. Until 1998 stringent conditions will persist and domestic consumption is expected to grow only by 1% per annum, as from then the growth may reach 3.5% annually through the year 2005. This drop in the consumption level reflects the loss of purchasing power of wages occurred in 1995 and 1996, a condition contributing to Argentine competitiveness in the present context. This wage fall permits savings since the aggregate global demand is less impacted due to the strong growth in Argentine exportations, whereas imports grow at a slower rate focusing on capital goods and inputs.

Exportations are expected to grow at rates ranging from 7.3 and 8% annually between 1996 and 2005, whereas imports, after growing by 10.9% in 1996, will only increase at annual rates between 5 and 5.8% showing a falling trend towards 2005.

These expectations result from the current macroeconomic situation, from the 1995/6 adjustment and from the prospects of international trade for Argentina assuming a successful international integration through both the Mercosur-European Union agreement and the NAFTA with USA support, and the influence of said blocks on the trade with Asia.

To estimate future changes in the investment rate some specific considerations and assumptions were made. Firstly, the 1994 level of investment shall gradually be reached towards 1997 but more concentrated in the productive activities than in the service sector (which characterises the first phase of the current strategy).

Secondly, the incremental capital/product ratio shall grow to exceed the national average value as the idle capacity generated by both the 1990-94 transformations and the 1989/90 and 1995 crisis is occupied. Investment shall focus in the exporting activities but keeping the building sector at a higher rate than in the last decade.

Finally, the election year (1999) is expected to have a negative impact on the growth of investment. Then, the incremental ratio shall be relatively decreasing to stabilise again at the national average value.

In this way, the Gross Investment/GDP ratio shall remain at around 23.5% to 25%, slightly higher than the 1994 level. The resulting average rate for the growth of investment shall be 4.3% between 1994 and 2005.

Projections start at the historical official data and it is estimated that the idle capacity is large. This means that the capacity to increase exportations by limiting domestic consumption still exists but new investments should be channelled to the productive activities in order to maintain the growth of exportations.

It is considered that there has been a peripheral modernisation of the manufacturing sector favoured by the relative price system. However, it is considered that most of the investment in 1991 and 1994 has been directed to the privatised utilities.

However, there existing large idle capacity, peripheral modernisation having taken place and there having been investment in industries that have improved competitiveness, perspectives for international trade are favourable, particularly considering the effect of the 1995 crisis on productivity and the favourable conditions for international integration (MERCOSUR-EU).

4.1.3 Hypotheses on sectoral growth

We are analysing below the assumptions underlying the total supply and demand projections from the perspective of the sectoral composition of growth.

Growth of the industrial sector

A more detailed analysis has already been made of the global consistency between the foreign trade and industrial development evolution assumptions. Said analysis continues to be at a relatively aggregate level and is tentative, subject to multiple and likely variations and combinations. However, it has the merit of revealing the assumed relations.

The methodology was the following: two growth rates were taken for each industrial branch, one linked to the development of the domestic market and a different one linked to the foreign market. Then, both rates were weighted using a rough estimation for the contribution of both markets to the value of industrial production for each manufacturing activity. This rate was applied to the physical volume of industrial activity indexes. An analysis was made of the dynamism of each branch and also of what this implied with respect to historical levels. Even when the industrial sector has suffered dramatic transformations in the last 25 years, the comparison between the past and the projected evolution gives a clearer idea about the reasonability of the goals fixed for the scenario, both in terms of production capacity and of required investment.

The average growth of the industrial sector resulting from these hypotheses is 3.8% annually between 1995 and 2005. See Figure 16.

As can be observed, after 1999 the slope of the curve changes reflecting the impact of growth in domestic consumption (it should be remembered that between 1996 and 1998 increase is very slight).

94

Figure 16 Industrial quantum index
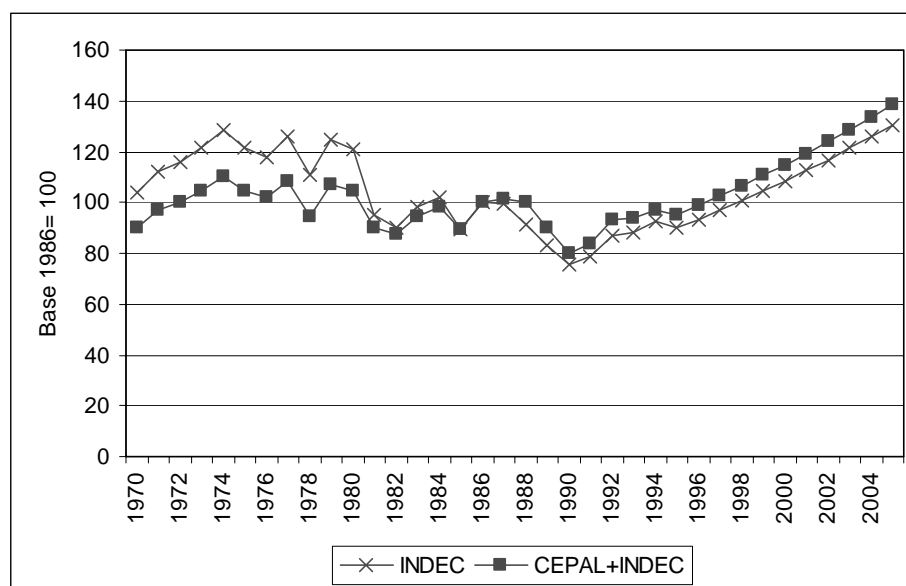
The greater exportation dynamism lies in branches having very low exportation levels at
present: 384-transportation materials and 355-rubber products (15%); 341-paper and by-
products and 356-plastic products (10 to 12.5%); textiles, garments and leather (10 to 7%).
Exports from other branches, like 311/312, 313-food and beverages, 351-chemical
products and 352-other chemical products, are expected to grow by 6 to 7% annually, but
starting from a relatively high exportation level.

Regarding the industrial growth linked to the domestic market, the hypotheses attempt to
capture the domestic consumption and inter-industry impacts. The total industrial value
added grows by less than 2% between 1994 and 1999 and by 4.5% between 1999 and the
year 2005, being the average for the period, 3.8% annually.

Growth of the agricultural sector

To forecast the agricultural growth, differential hypotheses were assumed for growth
linked to exportation, to industrial demand and to domestic consumption.

The methodology was the following: the ratio exports/production value was determined
by category of products. At the same time, it was necessary to determine what would
happen with agricultural productivity in order to understand the meaning of the
agricultural growth targets in terms of the total cultivated area.

It was assumed that grain exports would grow by 8%, total production to 5% and
agricultural productivity by 2.5% annually. This growth is made possible by the
favourable prices in relation to imported inputs, which are assumed to remain constant.

At the same time the grain demand by the food industry is expected to grow as a result of Mercosur and of the greater European opening under the framework of the Mercosur-EU agreements[25].

Regarding oil seeds, projection implies to maintain and even slightly increase the dynamism prevailing in the last 15 years. This assumption is based on the excellent opportunities and competitiveness shown by the oil industry and on the growing demand from abroad for these products. Production is assumed to grow by 7% annually, whereas exportations would grow by 11.5%. Productivity would increase by 2.8% for the reasons stated above.

As for the fruit production, a more moderate growth of only 2.5% between 1995 and 2000 and 3.5% between 2000 and 2005 is expected. The causes accounting for this situation are very complex and are basically related with domestic market problems and with the difficulties encountered for exporting in view of the growing international competition. Even when demand shall grow for juice and marmalade, costs constrain the competitiveness of Argentine fruit.

Figure 17 shows the evolution of the total agricultural production, of the agricultural sector value added and of the cultivated area, resulting from the adopted hypothesis.

Figure 17 Evolution of agricultural production
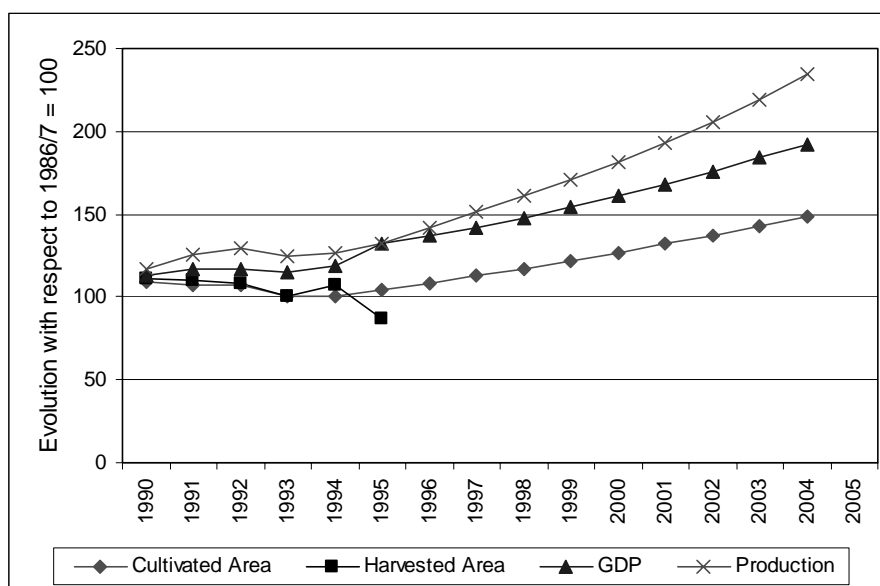
Note: Assumptions: Grains 5% annually; oil seeds 7% annually; fruit 2.5% and 5.5% annually. Agricultural productivity grows 2.5, 2.6 and 1% respectively.

Source: Elaborated by the author. Historical data based on the Secretary of Agriculture, Cattle Raising and Fishing.

As it can be appreciated, by 1999/2000 the cultivated area index will be similar to the prevailing in the middle of the prior decade. On the other hand, production level will be higher than that reached after 1995. This would be feasible only if an agricultural

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[25] However, projections are slightly higher than those arising from the analysis of the FAO, 27th period of sessions, November 1993.

consistent policy is applied and the relative recession that the sector suffered in the last few years is reverted.

The value added growth rate would be 3.9% until 1999 and 4.8% between 1999 and 2005.

Growth of the other sectors

The hypotheses adopted for the other sectors have been of a more global nature, although they keep relation with specific assumptions.

So, in the mining and quarry sector the weight of oil and gas production has been contemplated as well as the declination of the former and the recovery of the latter as from 1999/2000. This sector will grow 4.8% between 1995 and 1999/2000 and only 2% between 1999/2000 and 2005. It is assumed that the mining activity development shall be decisive after year 2005.

The electricity, gas and water sector shall continue to grow slightly above the rest of the economy such as in the past. This is due to several concomitant factors.

The water supply sector has been relatively lagging. Provincial water companies are expected to be privatised during the period of this study with international financing. The gas and electricity sectors have been mostly privatised and if the current relative prices can be maintained, there is likely to grow at high rates. Some provincial companies remain to be privatised, which will make it possible to dynamise growth, taking into consideration the low cost of access to the privatised assets such as has been the case in Argentina so far. The growth of this sector is estimated at a rate of 3.2% between 1994 and 1999/2000 and 4% from 1999/2000 to 2005.

As for the construction industry, this scenario assumes that the 1994 levels shall be reached only towards 1999/2000. The 1995 retraction was particularly acute in this sector. After 1999/2000 the expected average rate is 4.2%, the same as the 1999/2000 and 1995 rate.

The transport, storage and communications sector growth shall be 3% between 1994 and 1999/2000 and 5.7% between 1999/2000 and 2005. This is the result of calculating the "historical" ratio between the growth of the productive activities and this sector in particular.

In the case of financial services, growth has been assumed to be practically zero with respect to 1994 but almost 3.2% with respect to 1995 to 1999/2000. In this case the 1995-drop is consistent with the crisis that Argentina went through. Later growth is slightly higher than that of the total GDP.

The service sector, mainly affected by the governmental activity, shall grow very slowly. The expected level for 1999/2000 is only 3.2% above that of 1994 and increases to 2% annually with respect to 1995. This rate is expected to prevail all through the decade. The commercial sector shall grow by 2.4% between 1994/5 and 1999/2000 and by 6.5% from 2000 to 2005. The slow pace between 1994/5 and 1999/2000 reflects the deceleration trend of domestic consumption but is set-off by the recovery of exportation and by the greater commercial diversification that the open economy model allows. After the year 2000 it reflects the multiplying impact of increased domestic consumption.

4.1.4 Investment

This scenario assumes that growth until 1996/97 may be based on using the idle capacity and taking advantage of the differential prices for the domestic and foreign markets as a

way to maximise profit. However, the food, paper, chemical products, rubber, plastic, machinery and electric equipment and vehicles sectors need to increase their capacity in order to achieve the expected growth rates. It is clear that this shall depend on the evolution of international trade, but is assumed that the steps taken in Mercosur and the extra-regional integration processes shall not come to an end. It is also clear that the economic and political players are aware of the difficulties that would be created by not growing even at the modest levels taken for this scenario.

Given the excellent return on investments that Argentina offers in the dual pricing and decreasing labour costs context, it is assumed that the expected investment level is feasible though not easy to reach. These rates are 21.6% of the GDP in 1996, 22.9% in 1997 and 24.2% in 1998.

The investment amounts shall be lower than the historical values of 1994-1997, but, differently than in the 1989-94 period, shall focus in the agricultural, industrial, mining and energy and transport sectors. The modernisation of the service infrastructure and the recent reconversion of some manufacturing activities may facilitate this process.

4.1.5 Productivity and employment

Productivity has increased substantially between 1990 and 1995, as a consequence of this and of the changes in the job and productive structure, unemployment rates have climbed to very high levels in 1995/96.

These high unemployment rates, even if declining, would remain high until 1997 to then recover their regular level. This trend is consistent with the evolution of consumption and with the pre-election climate prevailing in 1998/9. It is assumed that, by the year 2000-2005, if there are no substantial increases in productivity, full employment shall be reached given the assumed activity levels and the average conditions of Argentine economy.

4.1.6 Evolution of consumption and domestic saving

As has been stated several times, the absolute level of public and private consumption shall decrease in this scenario relative to 1994 levels and the trend will continue until 1998/99. Then it shall grow gradually.

This behaviour is necessary to reduce the growth of imports and is the result of the 1995 adjustment, which extends to 1997/98. In the same way this is what allows exportable balances assuming that foreign demand is guaranteed by Mercosur and the international commercial integration.

These hypotheses induce an increase in the domestic saving rate reaching some 22 to 24% of the GDP according to the investment levels required by the model. In terms of per capita consumption, it is clear that this scenario assumes a substantial reduction with respect to 1994 and that the reduced level will be maintained in time. Considering the changes in the distribution of income, this shall mean consumption levels lower than those of 1986 for a portion of the population, particularly if we take into account what was said about the actual GDP level reached between 1990 and 1995.

4.1.7 The foreign accounts

This section details the hypotheses made about the behaviour of foreign sector in terms of: exports, imports, balance of payment and expected evolution of the foreign debt.

Exports

Total exports will grow at a rate of about 7.5% annually after 1995. The dynamism of the different sectors shall depend on the level reached until 1995 and of the success of foreign trade strategies. Thus, primary exports shall grow by 7.9%, agroindustrial 6%, industrial 9.9% and energy only 0.8% between 1995 and 2005, taking into account the declination expected for 1999/2000 in the oil exportations and the partial offsetting achieved by natural gas exportations.

As for primary exports, growth rates are 8% for grains, 11.5% for seeds and fruit, 11% for fish and seafood and the remaining ones are expected to grow only by 4.5%.

Within agroindustrial exportations, fats and oils rank first at a 7.5% annual growth rate and solid wastes is expected to grow 7%. Both are related with the production of oil seeds. For the meat sector, the rate continues to be very low, 3%; fur and leather exportations shall grow 6.5% and the remaining items an annual average of 5%.

Manufacturing exports shall be the most dynamic and automobiles and vehicles are expected to grow 15% after the investment made to date. A large number of items in the plastic rubber industry and others shall globally grow by 10%. Chemical and related products shall grow an average of 6% and the remaining ones between 6 and 7% annually.

As for the destination of these exportations, it has been assumed that exportations to the Mercosur countries shall continue to grow though more moderately than in the past. The average exportation rate has been estimated at a 9.6% between 1996 and 2005, as compared to a rate of 23.5% between 1983 and 1995.

The hypotheses imply that Brazil importation from Argentina would account for about one fourth of the total Brazilian imports if the same grew at a rate of 3% annually in the next 10 years.

Imports

Total imports shall grow by 5.9% annually in this scenario between 1995 and 2005.

The adopted hypotheses attempt to reflect the globalisation conditions in a context of limitation of domestic consumption with a slight worsening of the income distribution.

The most dynamic imports in this context are capital goods and inputs with rates of 15% and 12% for 1995/96, 6% for 1996/1999/2000 and 4.5% and 5.5% for 2000 through 2004/5.

As for the origin of imports, those from Mercosur shall grow by 16.5% annually between 1996 and 2005 as compared to a rate of 18.5% between 1983 and 1995.

This hypothesis reveals the trend assumed for trade with Brazil. In this case the assumption is that if exportations from Brazil grow steadily by 3.5% annually, almost one third shall be to Argentina.

The balance of payments

The growth of surplus in the balance of trade shall be slow at least until 1998. Thus, only towards 1999 it may be possible to obtain a positive balance in the current account, assuming that companies benefits will be reinvested in the country, which to a large extent sets off the need for greater capital inflow to finance this development pattern. The foreign debt/GDP ratio shall remain at a reasonable level, from 35.5% in 1995 to a

maximum of 36.2% in 1999. The annual growth of the debt is expected to amount to 2.9% between 1995 and 2005 or only 2.3% between 1996 and 2005.

4.2   Evolution of macroeconomic and demographic variables after the year 2005.

4.2.1 The evolution of demographic variables

The population shall grow at a rate of approximately 1.3% to the year 2010 and said rate shall be slightly lower for the following decades, 1.28% for 2010-2020 and 1.26% for 2020-2030.

The average size of households shall remain constant for the quinquennium 2005-2010, at about 3.8 persons per household, but shall be slightly reduced to 3.5 in 2010-2020 and to 3.4 between 2020 and 2030. Thus, the number of family units shall grow at a rate of 1.7% between 2005 and 2030. It must be understood that the average size refers to the data recorded during the last year of each sub-period.

The urbanisation rate shall reach 92% by the year 2030, but there shall be a greater number of persons living in urban centres of over 50,000 inhabitants. Table 8 shows the corresponding data.

Table 8   Population, family and urbanisation rates projections

Year	Population (thousand person)	Families (thousand families)	% of Urban Population
1995	34760.7	9075.9	88.4%
2000	37162.0	9702.9	89.6%
2005	39739.0	10375.7	90.6%
2010	42390.1	11067.9	91.2%
2020	48172.7	13381.3	91.6%
2030	54598.5	16058.4	92.0%

Source: IDEE/FB's estimation on the basis of INDEC-CELADE data.

4.2.2 The evolution of macroeconomic variables post-2005

The total economic growth rate is the result of the number of hypotheses adopted regarding sectoral growth (Table 9).

Table 9   Long term GDP growth
Annual growth rates in % and GDP values by sector in 1994 US$

SECTOR	GDP 1995	Annual rate 1995/2030	GDP 2005	Annual rate 2005/10	GDP 2010	Annual rate 2010/20	GDP 2020	Annual rate 2020/30	GDP 2030
Agricultural	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	488831
Industry	71874	3.8	104597	5.0	133493	5.2	221609	4.5	344162
Electricity, gas & 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
Transport/ communications	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	26908	4.1	400981	5.0	511228	4.4	789174	4.4	1215407

For the 2005-2010 quinquennium, the estimated growth rate is 5% annually and in qualitative terms the growth pattern is very similar to that for the former period (2000-2005). Thus, the economy dynamics will be based on a quick growth of exports (8.3% annually) and on a relative restriction of domestic consumption (3.4% annually but close to only 2% annually per inhabitant, which is a low rate in view of the substantial portion of the population having unmet demand).

Differently than in the former period, the dynamism of imports and investment are reduced in relative terms, even when the latter account for over 26% of the GDP during the target year of the sub-period.

From the sectoral standpoint, the following sectors show steady growth: agriculture (7.5% annually), mining (8% annually) and industry (5% annually).

The infrastructure sectors will grow above average but the relative dynamism of construction, commerce and services are reduced. This is the result, in the case of construction, of the restrictions imposed by the distribution and availability of private income and the limitations in the public investment, which shall continue to be restricted for a long period. In the case of commerce and the financial sector, the hypotheses show a slow trend to the rearrangement of the productive structure, distorted since the '80s as a result of the economic problems described in the diagnosis.

After the year 2010, economy will grow at a lower rate, 4.4% annually and this growth shall be driven by domestic consumption as much as by exports. For the decade 2010-2020, it has been assumed that consumption growth shall be near to 4.6% annually and exports shall grow by 5% annually, whereas during the following decade, consumption shall grow by 4.4% and exports by 4% annually.

In any case, long term growth is determined by the stabilisation of the exportation rates at 25 to 26% of the GDP (See Figure 18). The investment rates should be stabilised at 23-24% of the GDP and imports that accounted for almost 17% of the GDP should gradually decrease to account for 15.2% in 2020 and 14.3% in 2030 [26].

The greatest dynamism from the sectoral perspective shall continue to lie in the agricultural/mining and industrial sectors with a strong impact of construction during the last decade (See Figure 19).

According to assumptions about long-term growth, the productive structure would tend to be more concentrated in the productive activities (49.2% in 2030, against 43.1% in 1995), whereas service sectors would come down in relative terms.

Participation of the infrastructure sectors would be somewhat higher (8.1% against 7.3%), which reflects the nature of the development pattern.

From the standpoint of the productive structure, the main feature would be a growing relative importance of the primary sectors. Thus, the agricultural sector would have a share of about 12% of the total in 2030, against only 8.2% in 1995, whereas the mining sector would increase its share from 2.6% in 1995 to 4% in 2030. However, a relative consolidation of industry is expected, a trend that until the year 2010 would be based on few specialised exports, and then, because of the dynamism and consolidation of the

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[26] It should be remembered that these rates result using the 1986 price index, the last system of National Accounts officially available. However, this base exaggerates the opening rates of Argentine economy in the '90s, since the relative prices of imported goods are assumed as higher and the prices of internal goods are assumed as lower.

domestic market in the search of a better standard of living for the population. Thus, Argentina would grow at rates slightly above the regional average.

Figure 18   Argentina: Long term scenario 1995-2030
Per capita consumption, exports and imports
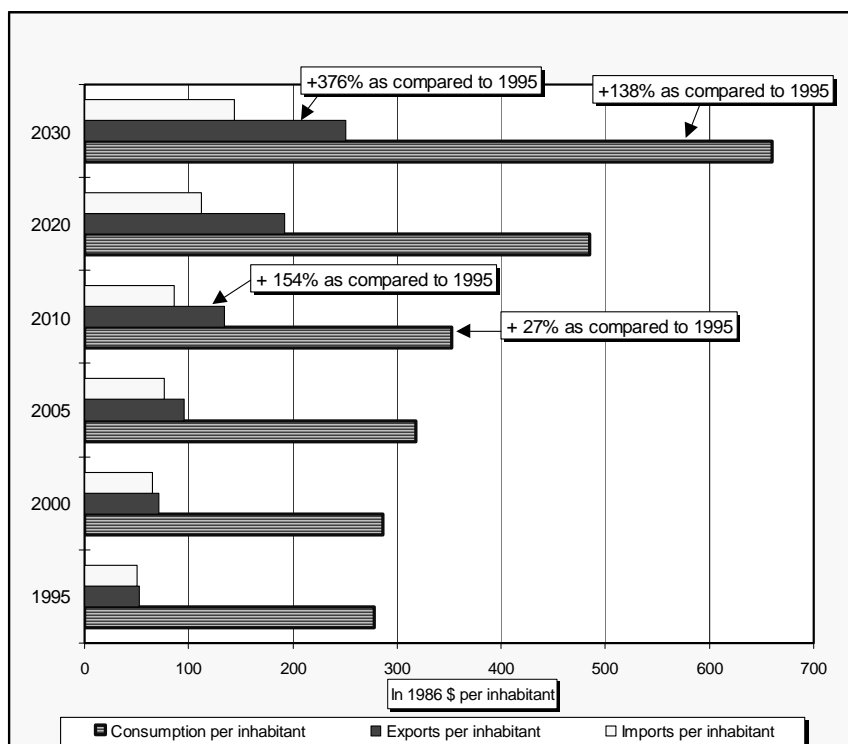
Source: IDEE/FB's estimation

Figure 19   Argentina: Long term scenario. Modification of the productive structure
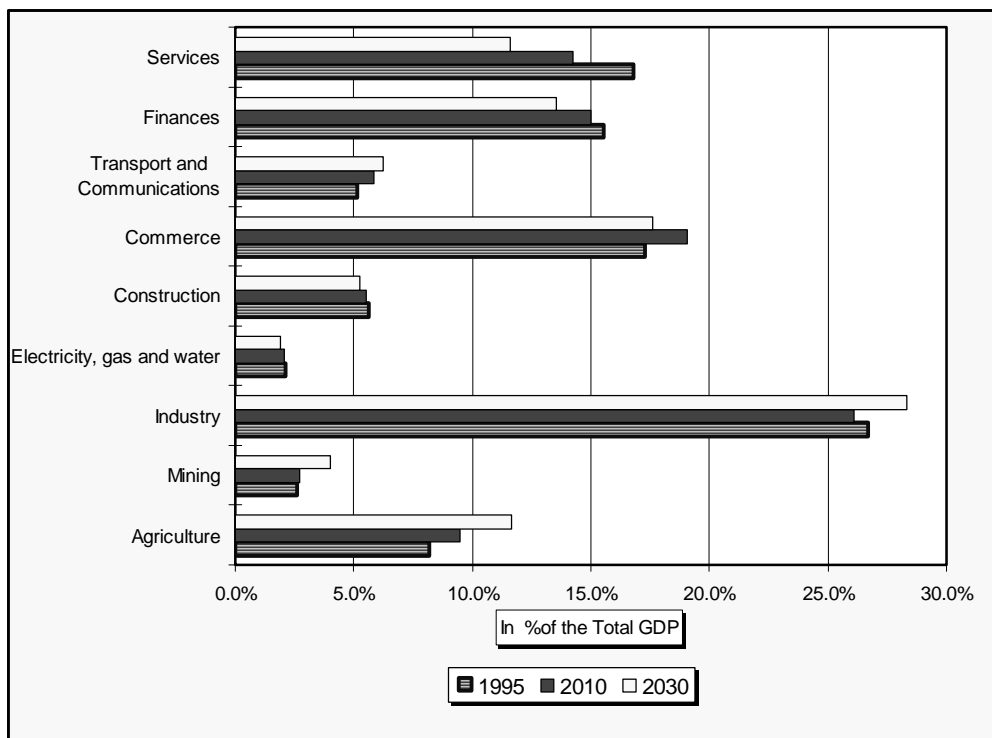
Source: IDEE/FB's estimation

A persistent surplus in balance of trade, achieved at the beginning by retraction of domestic consumption, would consolidate at a high Foreign Debt/GDP ratio during the first decades. However, such ratio will lessen considerably in the long term in spite of the increased financial outflows resulting from the transnational nature of property.

On the other hand, this commercial surplus would be favoured in the long term by relatively high international prices for primary and agroindustrial products.

Baseline scenario

1 Basic assumptions in the energy scenario. Investors' strategy.

To simulate the energy system's evolution it was assumed that in the future the government would interfere the least possible with private businesses in energy markets, implementing only certain policies aimed at:

1. controlling competition levels in domestic energy markets
2. promoting the creation of regional energy markets on competitive bases
3. guaranteeing future energy supply
4. improving energy efficiency

Following the methodological guidelines discussed in this report's Chapter III, no active climate change mitigation policy shall be assumed for the baseline scenario, being such actions reserved for the mitigation scenario. However, and as discussed subsequently, several of the assumptions shall have a positive impact on GHG emissions in Argentina, even in the baseline scenario, because of increments in energy efficiency and substitution between sources.

Within this context, private operators shall maintain the dynamics in place in the Argentine energy industries since their re-structuring, especially as regards the permanent search for new business opportunities. Such opportunities could appear both in local markets, where private operators would try to increase their share, and in inter-country trade, where operators would not only follow the official goal to encourage the creation of a regional market, but also become true energy inter-country trade promoters.

The following sections shall analyse the effect of such assumptions on:

1. the expected domestic energy prices,
2. technology innovation and energy efficiency, and
3. inter-country trade for different energy products.

Used as the starting point to simulate the Argentine energy system's future behaviour, whose results are presented in Sections 2 to 4 below.

1.1 Domestic energy prices

1.1.1 Crude oil and petroleum products

Oil and petroleum products' domestic prices were deregulated in January 1, 1991, including free exports and imports. Consequently, domestic prices are in line with international prices, being the WTI oil price in the New York market the marker price for the domestic market..

As presently Argentina is a crude oil net exporter (approximately 40% of the production goes to the international market), domestic crude oil prices are border prices (FOB), and

represent 89/90% of the marker price (US WTI), depending on national crude oil's characteristics.

It has been assumed that domestic and marker prices will maintain the present ratio. Based on the expected evolution of US WTI crude oil prices (Chapter IV), the domestic prices that appear in Table 10 have been calculated; international prices are also included for the sake of comparison.

Table 10   Oil prices' evolution

Year	US$ WTI US$/barrel	Domestic crude oil US$/barrel
1996	22.10	19.90
2005	24.00	21.60
2010	25.50	23.00
2020	29.75	26.80

It should be noted that this hypothesis provides the lowest domestic oil prices in the international context assumed. Actually, if oil companies maintained their present exploration policies, the limited reserve horizon could induce oil imports after the year 2010. In such case, domestic prices would move from FOB border prices to CIF border prices plus admission costs, with a 10/15% increase compared to assumed values.

Regarding petroleum products and for the sake of simplicity, it was assumed that the price of fuel oil would follow a similar trend to that of crude oil, as it is beyond the scope of this study to analyse any particular situations related to such fuel.

As fuel oil production costs can be computed in different ways, fuel oil suppliers could, within certain limits, sell fuel oil at very low prices as a competitive strategy against natural gas suppliers to maintain their market share. The income lost in fuel oil sales could be recovered through higher prices for motor fuels, as they are less competitive markets.

However, business alliances (or even corporate goals) among refiners and crude oil producers who also produce, transport and distribute natural gas turns "price wars" unthinkable between both energy products. Such situation justifies the constant price ratio assumption adopted for crude oil and national petroleum products.

According to crude oil prices' expected evolution and considering that present fuel oil prices range between 90/115 US$/Ton and that diesel oil's price is 300 U$S/m3, the following domestic prices evolution should be expected (Table 11):

Table 11   Fuel oil and diesel oil estimated prices

Year	Fuel oil US$/Ton	Diesel oil U$S/$m^3$
1996	90/115	300
2005	98/125	327
2010	104/133	347
2020	122/156	405

1.1.2 Natural gas

Wellhead natural gas price is free and depends on market conditions, whereas transport and distribution rates are regulated. Retail rates are established by adding to wellhead prices the authorised margins on account of transportation and distribution.

The theoretical ceiling price for natural gas would be defined on the basis of the market price for the substitute fuels expressed in terms of a common energy unit. Subtracting distribution and transportation costs from such value, the natural gas "net back" price at the head of the gas pipeline shall be obtained. Such calculation poses two questions, i.e.: what is the substitute fuel, and how shall gas transportation and distribution costs evolve?

In Argentina, and as seen in the energy diagnosis, gas replaces various fuels depending on the consumption sector. For the sake of the present calculation, fuel oil has been chosen as reference fuel because of its lower market price among eventual substitute fuels.

As regards transportation, it was assumed that transportation tariffs from fields to large consumption centres shall not change significantly, and a similar hypothesis was designed for distribution rates. Actually, transportation costs could substantially vary in the long term if the market expansion, both domestic and external, forced to build new pipelines from Neuquén and Tierra del Fuego fields. Although such issue deserves a more detailed and comprehensive analysis, a conservative hypothesis has been adopted for "net back" gas price calculation.

Table 12 shows the potential evolution of domestic natural gas prices in the hypothesis of a virtual convergence of market and "net-back" prices and considering the expected evolution of substitute fuel prices.

Table 12   Wellhead natural gas prices. Expected theoretical values
(US$/MMBTU)

Year	Northwestern Basin	Neuquina Basin	Austral Basin
1996	1.460	1.590	1.150
2005	1.687	1.809	1.395
2010	1.790	1.920	1.480
2020	2.092	2.244	1.729

It should be pointed out that compared to these theoretical values the 1996-average prices for the three above-mentioned basins were Northwestern: 1.218; Neuquina: 1.319, and Austral: 0.967. This means that calculated values are about 20% higher than present market prices.

The natural gas "captive" from power generation, i.e. plants fuelled with gas which would have been vented, should have a price lower than that which can be transported and/or distributed (non-vented gas). Therefore, gas costs for some thermal power stations located in Comahue and Salta could be lower than those calculated.

Besides the theoretical estimates, it should be noted that oil companies have stated on various opportunities that present wellhead gas prices are not profitable to invest in exploration. The long list of export projects and the possibility of materialising many of them would force to define a reserve/ production ratio representing the domestic market's minimum supply conditions so that the Energy Secretariat will authorise natural gas exports. Such value would define the need to invest in exploration and determine the minimum wellhead price.

Additionally, market conditions for Argentine gas (volumes and destination) shall influence the transportation and distribution infrastructure required to placing the gas in the market, whose cost shall have an impact on the maximum acceptable wellhead gas prices.

Consequently, domestic gas price in the future shall rely on the following variables: the border price of substitutes (which in turn depends on whether Argentina is an oil and petroleum products' exporter or importer); export volumes; investment needs in exploration and transportation and gas business-related players' capacity to exert pressure.

For this study, it has been assumed that in the long term the gas price will tend to the "net back" value, even when for the moment the pressure exerted by producers to expand their business increases market competition and renders prices below the substitute fuel's calorie value.

1.1.3 Electricity

Electricity retail rates result from adding to the Wholesale Electricity Market (WEM) prices the distribution margins contemplated in the respective concession contracts. The WEM prices, in turn, depend on the demand level (domestic and net foreign trade balances), the technical characteristics of the generating units, the share of hydroelectric generation (relying on hydrological conditions), and fuel prices (natural gas and petroleum products).

As thermal installed capacity is enough to absorb water in-flow fluctuations and considering that this is a long-term study, hydroelectric power stations' contribution resulting from mean hydrology has been considered. In future, once Yacyretá goes on stream at its design headwater level, hydropower stations are expected to progressively lose share in local generation, due to the opportunities offered by gas turbine improvement and the availability of natural gas to be burnt in power stations.

To the extent that new generating capacity is mostly based on fossil fuel generation —as expected—, most of the power stations shall be located in consumption centres, unless natural gas' regional prices offer substantial comparative advantages. If gas reserves to be used in the future were those of the Austral basin, distance prevents locating electricity supply close to gas fields. In such a case, the incidence of electricity transmission costs on electricity prices shall be minor while the incidence of gas transportation costs will be major.

Therefore, the electricity wholesale price shall increasingly rely on gas-fuelled generation. The ratio between both prices shall depend on the heat rate of the last unit, i.e. the one that establishes the WEM clearing price, disregarding eventual changes in transportation costs and marketing margins for distributors.

As for thermal efficiency, generators' strategy seems clear: to renew their plants resorting to international state-of-the-art technology to improve their market competitiveness. It has been assumed that this trend will not only be maintained in future but will also grow.

As a result of such observations, it can be expected that electricity prices shall be strongly tied to the natural gas market evolution, whose price shall be a leading price, within the margins left by crude oil's expected evolution in the international arena.

However, the impact of substantial electricity trade with Brazil on domestic wholesale prices is still to be analysed. Expectations differ between the electricity sector agents and

its consequences shall rely on the characteristics and volumes such exchanges shall have in the future. Pricing mechanisms in the Argentine WEM add exports to demand and consider imports as a fictitious machine. Therefore, their role is crucial in defining domestic electricity prices. The question lies on the volume of eventual imports from Brazil, associated to hydroelectric surpluses in the Brazilian system at a practically zero opportunity cost. Should the size of such imports be significant, strong oscillations could occur in WEM electricity price.

1.2 Technological innovation and energy efficiency

The search for business opportunities in a competitive environment shall generate contextual conditions favourable to technology innovation and further increase in energy efficiency, both in energy supply and in exporting-oriented productive activities.

The following paragraphs summarise the assumptions made in such sense for building the baseline scenario, where, besides players' expected strategy, specific regulations are also discussed.

1.2.1 The oil industry

In the oil industry, especially in crude oil production, there is a trend towards the use of new technologies that improve productive efficiency. By way of example, this innovation has allowed to reach a 50%-recovery factor in some fields. Such values, significant at international level where 35% is the average, are remarkable in Argentina where 18% is the average recovery factor.

According to the field operator's opinion, the oil recovery factor's growth in existing fields shall significantly contribute to increase reserves, reduce exploration efforts and resulting investment needs, and increase the long-term sustainability of intensive oil production.

On the other hand, in Argentina oil has been historically sought only in structural traps, leaving aside stratigraphic traps due to their relative higher complexity. Lately, new seismic prospective techniques have been introduce that would enable to detect oil deposits in stratigraphic traps, located in already mature oil fields.

Oil producers' strategy is expected to be oriented at incorporating state-of-the-art technology, significantly improving recovery factors and extending potential exploration areas to materialise the growth and continuity of their activity. However, oil industry is going through a transnationalization process that could lead companies to decrease investment in local exploration as long as better opportunities appear abroad, where activities are already being carried out by such companies.

1.2.2 The natural gas industry

In the natural gas chain, and even when a slight improvement in own consumption has been assumed associated to transportation in gas pipelines, the key element to measure its efficiency is the amount of gas vented in gas fields. Gas venting has been a permanent problem in hydrocarbon production in Argentina, and even reached 25% of total production in 1980. During the eighties, vented gas percentage decreased as a result of specific regulations that capped venting, however, it accounted for 12% of production in 1990.

As of 1993, the Energy Secretariat enacted much more stringent regulations on gas venting, putting a cap of 1 m^3 of gas released to the atmosphere by each m^3 of oil drawn out for the year 2000 with intermediate goals during the transition period.

Substantial differences were observed when such regulation first became current, between the goals established for vented gas and really vented volumes. Starting in 1997, however, a more severe attitude by the Energy Secretariat in the control and the authorisation of exceptions to the regulations resulted in a substantial decrease in vented gas volumes.

To the effect of this study, forecasts on strong gas venting limitation in oil fields have been incorporated in the baseline scenario to stabilise on 2% of the production after the year 2010, even when this goal constitute a clear mitigation action implemented by Argentina at its own cost. It should be emphasised that, as a non-Annex I country, Argentina has no international commitment to reduce GHG emissions according to the terms of the Framework Convention on Climate Change and the subsequent resolutions of the Conference of the Parties. According to private estimates, the investment required to reduce vented gas volumes would amount to 350 million dollars and could affect domestic oil production further increasing the above-mentioned direct cost.

As for distribution, natural gas and electricity distributing companies should be expected to increase their competition to attract end-users to improve distribution networks' utilisation factors, especially in large urban areas. Such higher competition shall materialise in air conditioning, and eventually in low temperature preservation and cold storage in industrial facilities and massive food marketing centres.

Gas distributors could try and capture air conditioning in new buildings promoting counter-seasonal consumption, a task that has already been started with relative success. Electricity distributors, on their part, are already promoting the replacement of gas heating by electric heat pumps.

Although from the standpoint of the overall energy efficiency, direct natural gas burning is more efficient, the reduction in building costs could attach a certain advantage to the electricity solution for space heating. In any way, it was estimated that the potential impact of a higher penetration or loss of share in such use on both sources' total consumption would not be significant, in spite of efforts made by distributors.

Penetration of one or the other source could be tied to the dichotomy between those who support investment costs and those who cover the operating and maintenance costs. In the industrial and commercial uses there is one single agent, therefore decisions shall be tied to the expected evolution of relative prices in both sources and the easier management of electric appliances. In the residential sector, the source that offer lower investment costs could be favoured, when speaking of houses built for their subsequent sale.

1.2.3 The electricity industry

In electricity generation it was assumed that ongoing competition between generators would increase the trend to retrofit existing thermal power stations to highly efficient combined cycles, with a gradual decrease in heat rates. Power stations of this type presently under construction already have a 52% thermal efficiency. It has been assumed that power stations started up towards the end of the period under analysis could reach 57% thermal efficiency.

Such high performance levels would be reached adopting the most efficient technologies available in the international equipment market and burning almost exclusively natural gas. The use of diesel oil would be limited almost only to winter time when gas burning is limited to power stations located in load centres.

Total efficiency increases in power generation shall reach even more significant values, as seen in Section 3 below, as such power stations substantially increase their share in total thermal generation by replacing lower performance existing facilities.

In the distribution stage, distributors are expected to encourage a better use of distribution networks. Such strategy would have two overlapping effects. First, efforts to lower distribution losses would increase, reducing the extremely high values reached at the beginning of the nineties. In the scenario building, it has been assumed that the distribution losses would amount to about 9% after the year 2000, therefore total transportation and distribution losses would hardly exceed 11% of net electricity generation.

Secondly, distributors' active participation was assumed in the implementation of rational use of energy programs involving load management, given their interest to postpone investments in network expansion within a framework of fast electricity consumption growth.

Within this context, electricity distributors would implement energy efficiency programs both for lighting and continuous uses (low temperature food preservation), in which energy efficiency is expected to improve.

Finally, distributors' strategy to increase their share in end-use markets, especially vis-à-vis natural gas, shall be maintained only to the extent that new electricity uses truly contribute to improve the load factor. Presently, air conditioning is practically considered as an electricity specific use whereas space heating, cooking, and water heating are mostly supplied by natural gas. In spite of this specialisation, the electricity annual peak load is still being recorded in winter, although summer and winter peaks are very close. Increasing the use of electricity for heat purposes could very well raise the annual peak load thus decreasing the network utilisation factor and accelerating the need to expand, against the interest of electricity distributing companies.

It has therefore been assumed that the effect of competition to capture end-use markets will have a reduced impact on both sources' final demand.

1.2.4 Energy efficiency in end uses

The opening up of the economy offers local users the latest generation equipment and appliances available at the international market. The impact on energy efficiency shall depend on the cycle and renewal speed of end-use appliances, the growth in capital investment and existing capital goods' renewal velocity.

In the case of end-use appliances, efficiency improvement shall be strongly tied to income levels. Higher income sectors are expected to rapidly achieve energy efficiency standards similar to those of industrialised countries, as efficient appliances shall become available in the local market.

On the other hand, industrial activities more exposed to competition at domestic or international markets, as well as those in which the energy bill is an important cost component, shall be forced to update technically in order to meet international standards.

Having said this, the baseline scenario should not be expected to be one where technology and state-of-the-art are frozen. On the contrary, in the scenario building, the international trend towards technology improvements has been incorporated and different pace for local technology renewal was assumed depending on consumption sectors.

On the basis of considerations made in this report's Chapters IV and V on the international context and the Argentine economy's expected development, a gradual increase in end-use energy efficiency was assumed. To that end, aggregate indicators were used (e.g. energy intensity, specific consumption or the energy consumption elasticity with respect to the activity level), assuming that same shall have a downward trend, both in production activities and family uses, according to the degree of saturation.

In Section 2 below, the specific hypotheses on energy efficiency adopted for each end-use sectors are presented together with the results obtained.

1.3   The foreign trade of energy

As already mentioned, local energy producing companies are expected to encourage their respective markets' expansion by exporting part of their production. The following paragraphs summarise the strategies and exports hypotheses adopted for each energy source in the baseline scenario:

1.3.1 Oil and petroleum products

In a context of intensive use for natural gas, oil companies are expected to maintain the present expansion trend through crude oil exports, while the foreign trade of petroleum products shall remain a marginal activity to the sole effect of balancing supply and domestic demand.

Present foreign markets for national crude oil are mainly Brazil and Chile. It was assumed that in the long term exports will mainly go to Chile and the Brazilian market shall rely less and less on crude oil imports. Brazil's growing self-sufficiency in oil supply could be achieved by intensifying Petrobrás' oil exploration or through Braspetro's consolidation at international level, or through the up-stream opening within the Brazilian territory to attract foreign capitals to invest successfully in exploration, and most probably through a combination of the three mechanisms.

The expansion of oil activity in the country, in spite of technological improvements, could be limited by Argentine oil companies' internationalisation, splitting their investments in exploration both inside and outside the national territory. The stability assumed for the international price of oil shall enhance the trend towards developing activities in more profitable areas than the Argentine basins, such as Venezuela, for instance, where such companies are already acting.

In such context, Argentine crude oil exports could gradually decrease after the year 2005, and, eventually, become imports if exploration efforts do not succeed in ensuring enough reserves to supply the domestic market, as higher annual discoveries than in the past would be required.

1.3.2 Natural gas

Oil companies' interest in increasing their fields' production, together with stronger gas venting restrictions, shall encourage the search for new markets for the Argentine natural gas, including exports to neighbouring countries. As previously stated, the companies' interest shall be favoured by the authorities intention to promote regional markets' creation on a competitive basis. However, and as each export contract requires a specific official permit, authorities shall have a chance to test the long-term sustainability of the business dynamics depending on the gas reserves' evolution.

It is beyond the scope of this study to analyse in depth the country's true possibilities to become a key gas supplier in the region. Consequently, to build the scenario, numerous projects were analysed and those with greater chances to materialise were selected. The complete list of gas pipelines and gas volumes committed, including those that are presently operating, read as follows:

- Methanex gas pipeline, between Argentina and Chile. Volume to be exported: 2 millions m³/day. Start-up date: end of 1996.

- Gas Andes gas pipeline, from the province of Neuquén to Santiago (Chile). Volume to be exported: 5 millions m³/day from start-up date (1997) to 2003. After such date, the volume shall increase to 8 millions m³/day.

- Neuquén-Concepción (Chile) gas pipeline. Volume to be exported: 1.5 million m³/day, start-up date around 2003.

- Atacama-Tocopilla (Chile) gas pipeline. Volume to be exported: 5 millions m³/day, estimated start-up date 2003.

- Mercosur gas pipeline, gas from the northwestern basin in Argentina shall go to Paraguay, Uruguay, and Brazil. Volume to be exported: 15 millions m³/day. Estimated start-up date: 2005, although the maximum volume will be reached gradually between 2005 and 2015.

Such assumptions regarding natural gas exports are relatively conservative hypotheses compared to the proposal made by oil companies. It is however intermediate, compared to the two alternatives analysed by the Energy Secretariat in the report Prospectiva 1997.

1.3.3 Electricity

Regulation considers two different types of electricity inter-country trade: sales and/or purchases under firm supply contracts and contingent trade. Within the first category are both the international bids made by a Brazilian company to buy 1000 MW firm power in Argentina and the power station CHILGENER is building in the Argentine North to supply the Northern Chilean System. Contingent electricity trade have taken place between the Argentine and Uruguayan systems since 1980, although at a marginal scale as far as Argentina's electricity supply.

As long as natural gas supply is guaranteed for power stations at a competitive price, Argentine generators' strategy shall aim at business expansion by encouraging firm power exports. However, such possibility shall compete with Argentine oil companies' gas exports, probably associated to importing countries' generators whose business opportunities would be favoured by gas imports and restricted by electricity imports. The resolution of these conflict of interests between energy operators shall depend on distances to gas fields, as well as on the existence or absence of firm electricity and gas transmission capacity.

Additionally, certain countries could limit this type of imports on account of their own electricity systems' supply security. However, the size of the Brazilian system would admit substantial exports compared to Argentine consumption.

Contingent electricity imports and exports between Brazil and Argentina could be constrained in the future by transmission capacity and the national grid configuration. In general, such type of trade would be tied to the availability of hydroelectric surpluses, which would be more important and frequent in Brazil than in Argentina due to the mix and size of Brazilian generating facilities. Therefore, and except in sporadic loss of load situations, contingent electricity trade shall be imports by the Argentine system.

However, Brazilian hydroelectric surpluses' availability could turn Argentine exporters with firm power contracts into occasional suppliers in the local market, causing two effects. In the first place, Argentina's contingent power supply would increase beyond the transmission capacity of international interconnection lines. Secondly, it would increase the volatility of electricity prices in the Argentine market, as for contracted argentine generators the opportunity cost of energy not taken by Brazil is very low.

Besides the risks such case would imply for local generators whose income is not secured by contracts —exports or domestic sales— estimating future net electricity trade with neighbouring countries becomes uncertain.

There is no doubt, however, that electricity inter-country trade shall substantially increase through firm contracted exports and contingent imports of Brazilian surpluses. In both cases, the effective flows shall depend on hydraulic conditions in the Brazilian system.

In the baseline scenario and only for the sake of estimating future fuel consumption in electricity power stations, net exporting balance have been assumed to gradually grow to 2500 continuous MW in the year 2020.

In spite of such forecasts, important fluctuations in electricity power stations' generation during real operation should be expected, as enough installed capacity shall have to be available to enter into firm supply contracts, even when most of the time the flows could move in the opposite direction.

2 Final energy demand: sectoral and aggregate analysis

2.1   Introduction

Future final energy demand for the baseline scenario can be defined following two different criteria. In the first case, present energy efficiency is maintained constant giving rise to the so-called "*frozen efficiency scenario*"[27]. The second way is by assuming some kind of "natural" efficiency improvement without any specific market intervention to stimulate such improvements.

The *frozen efficiency scenario* is not realistic, even without any type of intervention or effort to decrease energy consumption, energy intensity shall decline, simply as a result of shutting down obsolete, less efficient equipment and replacing same by new ones.

It seems more reasonable to consider that the baseline scenario involves maintaining the energy consumption trend, especially regarding specific consumption, equipment's penetration (more efficient vs. less efficient) and rational use of energy actions that could be expected without altering prevailing policies.

Such second alternative could be associated to an approach called "*frozen dynamic efficiency scenario*"[28], which assumes shutting down obsolete equipment and exchanging it for new, more efficient models available in the market, without assuming the introduction of new technologies, still unavailable in the base year.

In the "frozen dynamic efficiency" scenario, the average energy intensity could decrease in time, depending on the production structure evolution and consumption sectors' role and, of course, on the efficiency of new technologies available in the market.

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[27]   UCCEE, Improving Energy Efficiency and Protecting the Environment, November 1997, Pages 44/45
[28]   UCCEE, op. cit.

114

The dynamic efficiency approach was used in this study to define, characterise, and establish the baseline scenario's final energy consumption, according to the statements made in Section 1 above. For each sector, the applied criteria shall be explained and, if necessary, their rationale, defining the changes expected even without any intervention policies.

Below are described the essential characteristics of each consumption sector, the guidelines defined for the scenario and the results obtained.

2.2   Residential sector

The residential sector is significantly relevant in the Argentine Energy Balance, with a share that has exhibited an upward trend in the 1980-1995 period, reaching 20.3% of Final Consumption in 1995, as a result of sustained and especially significant growth rate in the 1990-1995 period (4.9% annually).

As for the structure by source, consumption is strongly concentrated in distributed gas and electricity (jointly accounting for 80% of consumption), a concentration that has grown in the recent past (in 1980 distributed gas accounted for 40% whereas the present figure exceeds 61%). LPG ranks next, although with a clearly downward trend (from 21% in 1980 to 11.4% in 1995).

The trend evidences a strong substitution between sources, with a growing share of cleaner and more efficient energy sources. Historical trends' extrapolation takes population growth as explanatory variable.

A growing segment of consumed electricity is used for thermal purposes, replacing other sources in such use. The growing electricity penetration means a significantly higher elasticity with respect to the explanatory variable than that evidenced by other sources.

Thermal uses still accounted for by fuels (wood, distributed gas, kerosene, LPG, and charcoal) are gradually concentrating in distributed gas, although wood and charcoal still retain a certain share, especially because of cultural habits. However, a significant penetration of electricity in thermal uses has been assumed, e.g.: air conditioning (cold and hot) and cooking, besides "traditional" electricity uses.

Decreasing elasticity with respect to the explanatory variable were assumed for all the sources, in the understanding that technologic development will allow for growing energy efficiency in the sector's energy consumption. In such sense, higher efficiency is expected in lighting as a result of low consumption bulbs' penetration, the renewal of food preservation appliances and a reduction in consumption by other electric appliances. As refers natural gas, higher efficiency equipment shall be gradually incorporated, both for cooking, water and space heating.

Thus, fuel consumption's elasticity gradually decreases from 0.7 in 1990/95 to 0.5 in the 2010/2020 period, whereas electricity consumption's elasticity decreases from 1.83 in the base year to 1.00 toward the end of the period under analysis.

As a result of such hypotheses and the explanatory variable behaviour, the sector's total energy consumption and structure by source exhibit the values that appear in Table 13.

Table 13   Energy consumption by the residential sector

Source	1995		2005		2010		2020	
	Mill.GJ	%	Mill.GJ	%	Mill.GJ	%	Mill.GJ	%
Fuelwood	7.55	0.3	9.03	1.9	9.87	1.7	11.33	1.4
D.gas	203.78	61.1	291.07	60.7	351.03	60.3	492.69	61.1
LPG	37.97	11.4	39.46	8.2	39.24	6.8	33.98	4.2
Kerosene	14.07	4.3	14.29	3.0	13.97	2.4	11.33	1.4
Charcoal	8.37	2.5	11.16	2.3	12.95	2.2	16.99	2.1
Electricity	61.53	18.4	114.96	23.9	155.23	26.6	239.61	29.6
TOTAL	333.26	100.0	480.86	100.0	582.3	100.0	805.92	100.0

It can be noted that electricity and distributed gas concentration increases as both sources cover over 90% of consumption in 2020, whereas the total sectoral consumption increases 142% by 2020, with respect to the 1995 level.

The average annual growth rate is 3.6% for total consumption, while electricity grows at 5.6% and distributed gas at the same rate as the total retaining its share. The remaining sources regress, which implies rates below the total or even negative rates (kerosene).

Of course, rates do not remain constant along the twenty-five years. In the near future —until 2005— the rate is slightly higher (3.7%) and gradually decreases towards 2010 and 2020 (3.3% for the last decade).

2.3   Commercial and public sector

The commercial and public sector enjoys a relatively low share in the Argentine Energy Balance, although it has evidenced a significantly growing trend in the 1980-1995 period (accounting for 4.2% of Final Consumption in 1980, and 6.1% in 1995). However, its expansion was recorded mainly during the Eighties, as in the 1990/95 period its energy consumption decreased in volume, according to the Energy Balance data.

As for the structure by source, consumption is highly concentrated in distributed gas and electricity (accounting for 92.5%). Even when such concentration has grown in the recent past, it dates way back (in 1980 both sources accounted for 90%). The relative importance of each source has substantially changed. Historically, electricity has a growing penetration (36% in 1985 and 43% in 1995), while distributed gas evidences a certain regression (58% in 1990 and 50% in 1995).

The sources that follow are diesel oil and fuel oil, although their relative importance exhibits an extremely erratic behaviour.

The trend evidences a strong substitution between sources, with an important share accounted for by clean and efficient sources.

The explanatory variable used for historic trends' extrapolation is the activity level accounted for by the GDP.

Electricity is replacing other fuel in thermal uses. electricity penetration is expressed in a significantly higher growth rate than that evidenced by other sources.

Thermal uses still accounted for by fuels will be gradually concentrating in distributed gas, although both LPG and diesel oil will retain a certain share, and fuel oil will disappear completely.

Decreasing intensities have been assumed, because just like in other sectors, technologic developments will allow for growing energy efficiency. Thus, fuel consumption intensity is expected to decrease 2.5/3.0% annually, while electricity intensity initially would grow at 1.25% per annum (until 2005) and then would drop 1% annually.

As a result of the hypotheses assumed and the explanatory variable behaviour, the sector's total energy consumption and its structure by source reaches the figures that appear in Table 14. By the horizon year the energy sectoral consumption is expected to be 106% higher than base year values.

Table 14   Energy consumption by the commercial and public sector

Source	1995		2005		2010		2020	
	Mill.GJ	%	Mill.GJ	%	Mill.GJ	%	Mill.GJ	%
Electricity	42.58	42.8	72.28	52.1	87.63	54.7	122.34	59.8
D.gas	49.35	49.7	59.73	43.2	66.64	41.7	78.72	38.4
LPG	0.5	0.5	0.48	0.4	0.47	0.3	0.41	0.2
Diesel oil	6.57	6.6	5.65	4.1	5.09	3.2	3.30	1.6
Fuel oil	0.38	0.4	0.26	0.2	0.19	0.1	0.00	-.-
TOTAL	99.38	100.0	138.41	100.0	160.03	100.0	204.76	100.0

The above table exhibits a 2.9% average annual growth rate for total consumption, in the 1995-2020 period. Electricity, however, would grow at 4.3% per annum and distributed gas at 1.9% annually. The remaining sources' absolute values regress, implying negative growth rates (LPG, DO, and FO).

2.4   Transport sector

2.4.1 Introduction

The transport sector is the most relevant regarding its final energy consumption share, 33%, evidencing a very significant growth rate in the last 5 years (6.2% annually). The structure by sources is varied, i.e. although diesel oil and gasoline predominate, kerosene, compressed natural gas (CNG), electricity, and fuel oil participate as well.

In 1996, 47.5% of consumption was accounted for by diesel oil, a source that gained ten percentage points in share during the last sixteen years thanks to the relative prices' structure. Gasoline ranks next (36.4% of consumption in 1996) and is systematically losing share replaced by diesel oil and CNG —in 1980 gasoline accounted for 54.1% of consumption and in 1995 it had dropped to 39.1%—. CNG —a fuel developed towards the mid-eighties— still has a low share (6.8%), exceeded by JP1 (8.4%) but with a clear upward trend, considering it accounted for only 1.9% of the sector's consumption in 1990. The sector's total energy consumption amounted to 519.75 million Gigajoules in 1995.

Given its distinct role in energy consumption, the sources used and the resulting strong contribution to total GHG emission (32% of total CO_2 emissions in 1994), this was one of the sectors chosen to explore potential mitigation actions and analyse their consequences.

To that end, a detailed analysis was carried out, identifying consumption subsectors and, within them, the role of various transportation modes and means and the corresponding energy sources.

The considered subsectors are urban and inter-urban passenger transportation and cargo transportation. A description of the characteristics, from the energy standpoint, of each of those shall be given here in below.

Urban passenger transportation

This subsector's energy consumption was estimated in 175.45 million GJ in the base year, accounting for 33.8% of the sector's total consumption. It evidences a growing trend, driven by the car fleet increase and its higher use. In the 1990-95 period, consumption grew at a rate of almost 6% per annum, gaining share in sectoral consumption.

The transportation modes considered are private cars, taxis, urban buses, railways, and underground. Private cars include those used as "remises" (cars for hire with driver) given the impossibility to identify such cars separately.

Estimated consumption by mode allot a share of almost 82% to private cars, the major source being gasoline (84.4%), followed by CNG (12%), and diesel oil (3.6%). The trend exhibits a loss of share by gasoline and an increase both for CNG and diesel oil. It should be highlighted that, because of methodological reasons and the difficulty to estimate trips in interurban lanes, energy consumption by private cars includes both urban and interurban trips.

Urban buses rank second (almost 11%) in the subsector's total consumption. Buses' consumption is almost totally accounted for by diesel oil —there is a limited fleet fuelled by CNG, whose consumption go practically undetected at total subsectoral level—. Taxis burning gasoline, diesel oil or CNG make up the third group, accounting for 6.06% of the subsector's consumption and completing 98.90% of consumption with private cars and buses. It is important to point out that the major source in the case of taxis is CNG (47% of the mode's consumption), followed by gasoline with 39%.

The remaining 1.1% is accounted for railway and underground. The sources used in such cases are electricity (0.7%) and diesel oil (0.4%).

According to the estimates made, gasoline accounted for 71.5% of the subsector's total consumption in the base year, diesel oil 15%, and CNG 12.7%, the rest being accounted for by electricity.

Interurban passenger transportation

This subsector's total energy consumption was estimated in 37.09 million Gigajoules in 1995, i.e. 7.1% of the sector's total consumption. Its share evidences a downward trend, although consumption has grown at 3.7% per annum in the 1990-95 period.

This subsector involves the following transportation mode: road (interurban buses), railway (trains), and air (aeroplanes). As made clear in the previous item, cars are not considered, as their consumption is already included in urban passenger transportation.

Estimated consumption by mode render the following results: air transportation (jet fuel) is the most relevant: 61% of consumption —22.6 million Gigajoules—, followed by interurban buses (38.2% - 14.2 million Gigajoules) and, finally, railways (0.9% - 0.3 million Gigajoules).

Each mode is associated to a single energy source: jet fuel in air transportation and diesel oil in buses and railways. The share by mode is consequently the share by source: 61% jet fuel, 38% diesel oil.

Cargo transportation

Cargo transportation reached 307.2 million Gigajoules in 1995, accounting for the highest share in energy consumption for transportation (over 59%) with a slightly growing share

and clearly growing volumes (6% annually between 1990 and 1995), a rate higher than the sector's average.

The relevant transportation modes in this subsector are road (light and heavy-duty trucks), railways (trains), and river and sea-transport (boats and barges). Consequently, there are four means of transport, the most important one being road transportation by heavy-duty trucks.

Heavy-duty trucks account for almost 59% of the subsectoral consumption; concentrated almost totally in diesel oil, with a small share of gasoline. The shifting from railways, and river and sea-transport to trucks is enlarging its share in energy consumption, which grew over 7% per annum in the 1990-1995 period.

Light-duty trucks rank second, accounting for about 39% of the subsector's consumption; their share is relatively stable, growing at a rate slightly lower than the subsector's average. The structure by source is more diversified, i.e. gasoline, diesel oil, and CNG. Gasoline is losing share in favour of both CNG and diesel oil, albeit higher for CNG. However, gasoline still accounts for 67% of energy consumption, diesel oil 22%, and the remaining 11% are absorbed by CNG.

Diesel oil-fuelled trains account for slightly over 2% of the subsector's consumption, 6.25 million Gigajoules with a downward trend, at least since 1990. Railways lost 50% share in five years and absolute consumption values dropped.

The remaining 0.12% is accounted for by boats and barges, which also exhibit a downward trend both in relative and absolute values.

As a result of the estimates, it can be said that in the base year gasoline accounted for 28% of the subsector's total consumption, diesel oil 68%, CNG 4%, and fuel oil a very low percentage.

2.4.2 Scenario assumptions

As mentioned before, the baseline scenario assumes that the system's trends shall be maintained regarding development and dissemination of better technologies, penetration of both transportation modes and means and energy sources and actions aimed at acting on the passenger and cargo transportation depending on problems that may result.

In such sense, the baseline scenario assumes important changes compared to the present situation, especially in the long term. The hypotheses have been grouped under three large headings:

- Traffic organisation measures
- Substitution between modes
- Technical improvements and energy sources penetration

2.4.3 Traffic organisation measures

Changes related to urban, suburban, and interurban transportation have been assumed. In the first case, the following is considered:

- Construction of highways or belt roads in major cities (cities with over two hundred thousand inhabitants)
- Subways construction or expansion, or elevated railways construction in large cities

- Regulating private cars and buses' circulation in downtown areas.
- Ruling the entry of heavy-duty trucks to urban areas

Regarding suburban areas, the following is expected:

- Construction of new suburban highways, especially in Greater Buenos Aires, Greater Cordoba and Greater Rosario.
- New satellite cities as sleeping areas for large metropolis. That means: administrative activities in the cities and industrial activities in the periphery. Enhanced services in the periphery.

As for interurban transportation, the following has been considered:

- Construction of new highways: Mendoza-Federal Capital; Bahia Blanca-Federal Capital; Cordoba-Santa Fe; Tucuman-Cordoba; coastal highway from Federal Capital to Bahia Blanca.

2.4.4 Substitution between transportation modes and means

In this case, changes in the urban, suburban, and interurban sphere are also assumed. In the urban sphere, the following is expected:

- Increase in the penetration of urban buses to replace private cars.
- Subway and/or elevated trains penetration, replacing urban buses and private cars.
- Higher occupancy factors in all transportation means, especially private cars.

As for the suburban areas, hypotheses include:

- Switching from buses to railway in public passenger transportation.
- Switching from private cars to bus and minibus transportation.
- Higher occupancy factor.

Finally, for interurban transportation:

- Switching from buses to railways in the heavier transit lanes.
- Increasing the railway share in cargo transportation, replacing trucks.
- Increased use of combined railway-truck transportation.
- Increase in freight transportation by river.

2.4.5 Technical improvements and energy source penetration

Various hypotheses were developed regarding cars, buses, light duty trucks, and railways. In the first case, the following has been assumed:

- Higher performance
- Switching from gasoline to diesel oil and CNG.
- Launching of the first electric and hydrogen fuelled vehicles between 2015-2020. Expected penetration: 1% of the market by 2020.

120

Performance improvements considered shall be:

Table 15   Performance improvements

Fuels	1995	2005	2010	2020
Gasoline lts/100km	10.5	10.0	8.9	7.0
DO lts/100km	7.8	7.4	7.0	6.3
CNG m^3/100km	11.42	10.88	9.7	7.6

Engines' increased performance will result from a number of technological changes, among other: electronic control system and variable valve timing, material substitution, speed automatic, electronic transmission, number of valves per cylinder, cylinder reduction, friction reduction, changes in injection (multipoint injection), etc.[29].

Technical changes would result in 12 to 18% specific consumption reductions by the year 2010.

As regards diesel oil and CNG penetration, the following hypotheses have been made:

Table 16   Hypotheses for diesel oil and CNG penetration

Cars	1995	2005	2010	2020
Gasoline	84.4%	70.3%	62.5%	49.0%
Diesel oil	3.5%	11.4%	14.7%	19.8%
CNG	12.1%	18.3%	22.8%	30.0%
Electricity				0.2%
Hydrogen				1.0%

As for buses, the following has been considered:

- Penetration of CNG fuelled urban buses.
- Incorporation of hydrogen fuelled buses.

Hypotheses related to the growth of CNG fuelled bus fleet are summarised below:

Table 17   Growth of CNG bus fleet

Buses	1995	2005	2010	2020
Diesel oil	100%	86.6%	74.4%	55.4%
CNG		13.4%	25.6%	43.6%
Hydrogen				1.0%

The following performances have been considered:

Table 18   Performance of bus fleets

Buses	1995	2005	2010	2020
Diesel oil lt/100km	29	27.6	26.2	23.5
CNG m^3/100km		40.5	38.7	35.2

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[29] "Effects of Feebates on Vehicle Fuel. Economy. Carbon Dioxide Emissions and Consumer Surplus", US Department of Energy, February 1995

Changes expected in light duty trucks relate to:

- Improved performance.
- Switching gasoline and diesel oil to CNG.
- Launching of electric vehicles between 2015 and 2020.

Expected performance increases are summarised below:

Table 19   Expected performance increases

Fuel	1995	2005	2010	2020
Gasoline lt/100km	16.00	15.05	13.4	10.53
Diesel oil lt/100km	10.70	10.56	10.0	9.00
CNG m3/100km	17.70	17.54	15.6	12.25

Significant penetration of diesel oil and CNG have been considered, according to the following percentages:

Table 20   Penetration of diesel oil and CNG

Fuel	1995	2005	2010	2020
Gasoline	67.1%	32.4%	16.7	6.4
Diesel oil	22.4%	52.6%	37.5	38.2
CNG	10.5%	15.0%	45.8	51.7
Electricity				0.2
Hydrogen				3.5

As for commuting railways, a certain degree of electrification is expected, following these guidelines:

Table 21   Expected electrification for commuting railways

Trains	Transported passenger-km			
	1995	2005	2010	2020
Electric locomotives	53.2%	74.2%	77.8%	81.8%
Diesel locomotives and railcars	46.8%	25.8%	22.2%	18.2%

2.4.6 Results for the baseline scenario

As a result of the hypotheses assumed and the guidelines defined for the scenario, the LEAP model exhibits the consumption for the sector as a whole showed in Table 22.

The average annual growth rate for the whole period reaches 3.75%. CNG is the source with the highest growth (9.5% per annum), however CNG is expected to grow in the future at a lower pace than between 1990 and 1995 (35.8% annually) as it will be gaining share in total energy consumption. Electricity would be the second growing source (5.2% per annum), although its share is low, followed by diesel oil (4.4% per annum). The single source that exhibits negative rates is gasoline, as a result of substitution hypotheses and improvements assumed in performances.

Differences in subsectors' dynamic along the period result in uneven growth. While the urban passenger transportation is expected to grow at 3.5% average annual rate, energy consumption for interurban passenger transportation will grow at 2.4% annually and

cargo transportation will exceed 4% per annum. Thus, cargo transportation will be the highest dynamic subsector within the transport sector, as it is expected to follow the growth assumed for productive activities, especially the most dynamic ones: industrial commodities and productive activities related to natural resources. In such sense, it is to be pointed out that the cargo transportation growth becomes faster after 2005 and, especially, from 2010 onwards.

Table 22   Energy consumption for transportation

Source	1995		2005		2010		2020	
	Mill GJ	%	Mill GJ	%	Mill GJ	%	Mill GJ	%
Diesel oil	249.54	48.0	330.65	52.9	414.08	51.5	737.27	56.4
Gasoline	211.00	40.6	179.66	28.7	186.96	23.3	173.63	13.3
CNG	35.01	6.7	86.00	13.8	170.05	21.1	336.10	25.8
Kerosene/JP	22.58	4.4	26.34	4.2	29.76	3.7	35.86	2.8
Fuel oil	0.38	0.1	0.41	0.1	0.88	0.1	1.07	0.1
Electricity	1.25	0.2	1.77	0.3	2.25	0.3	4.40	0.3
Hydrogen							16.59	1.3
TOTAL	519.75	100.0	624.82	100.0	803.98	100.0	1304.93	100.0

Figure 20   Total consumption by transportation subsector
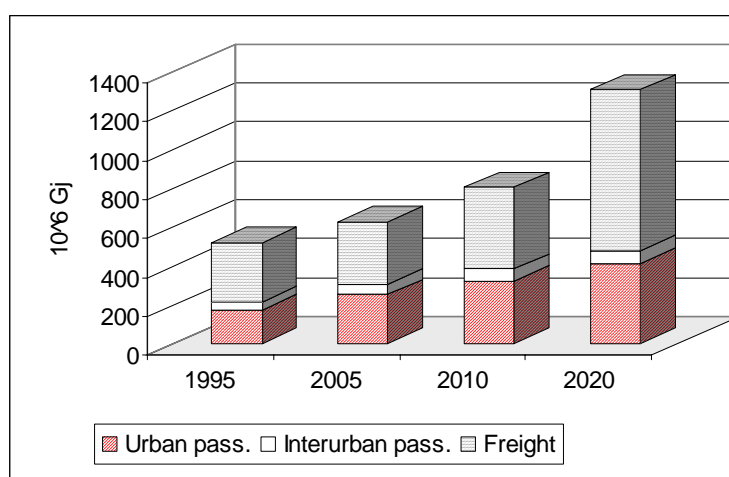
*Urban passenger transportation*

In the nearest future (2005/2010) energy consumption for urban passenger transportation will grow faster than the other subsectors, thus increasing its share in total consumption. However, in the long term it is expected to moderate its growth pace due to the impetus of the cargo subsector, the substitution between modes, technical improvements, and substitution between sources, thus retrieving almost the same share than in the base year.

With 411.4 million Gigajoules consumption in 2020, the subsector reaches 31.5% of sectoral consumption, accounting for over 86% of the sector's gasoline consumption and 27% of petroleum products.

Private cars remain pre-eminent, although their share decreases from 82% to slightly over 73%. Hypotheses related to substitution between transportation means enhance the role of urban buses (almost 19% of the subsectoral consumption), while the remaining means' shares exhibit slight variations.

In spite of being substituted by CNG and diesel oil, gasoline will remain as the major source, accounting for 36.6% of the subsectoral consumption in the horizon year. However, CNG will reach similar percentage (36%) followed by diesel oil, 25.5%. CNG's extremely rapid growth is totally justified by the historical behaviour, ever since its launching into the market. In spite of defining projection rates, which at most account for one third of the historic rate, the average annual growth rate amounts to 7.9%.

Figure 21   Urban passenger transportation
Consumption by source and transportation mode
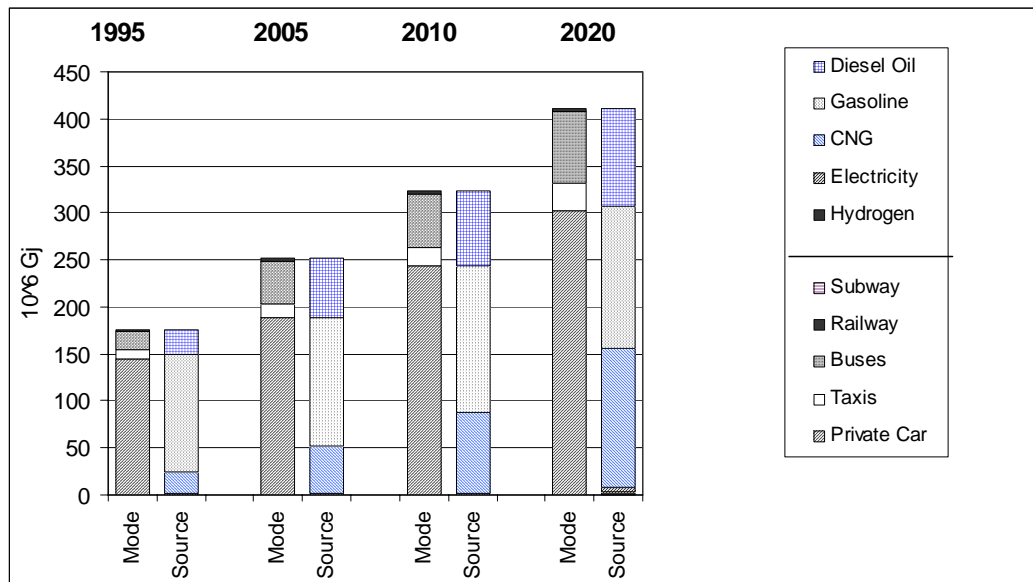
Regarding energy sources contribution, the following should be highlighted: diesel oil and CNG penetration for private cars and taxis; the relative importance acquired by CNG in urban buses (especially towards the horizon year) and the hypothesis of the first hydrogen-fuelled vehicles and electric cars launched in the year 2020. Hydrogen accounts for 0.9% of consumption and electricity grows from 0.7% to 0.87%.

The subsector shall be based on non-renewable sources' consumption; petroleum products still prevail; gas penetration permits a certain degree of diversification and involves a positive effect on the subsector's specific emission. Massive transport modes still play a relatively marginal role in subsectoral energy consumption.

Railways' growing electrification has been considered however, estimating that electricity's share in this transportation mode shall grow from 60% to 77% in 2020.

Interurban passenger transportation

The interurban passenger transportation exhibits a downward share during most of the period under analysis (growing slightly by the milestone year 2005), reaching in the horizon year a share 2 points below the one exhibited in the base year.

With 67.85 million Gigajoules in 2020, the subsector reaches 5.2% of sectoral consumption, accounting for the sector's total jet fuel (JP) consumption.

Given that energy consumption by private cars has been included in the urban passenger transportation and gasoline-fuelled interurban buses are no longer used, the subsector's consumption relies on diesel oil and JP, as aviation gasoline consumption is not very

significant. Consequently, consumption will rely on the same energy sources used at present, only petroleum products.

Figure 22   Consumption by source and mode
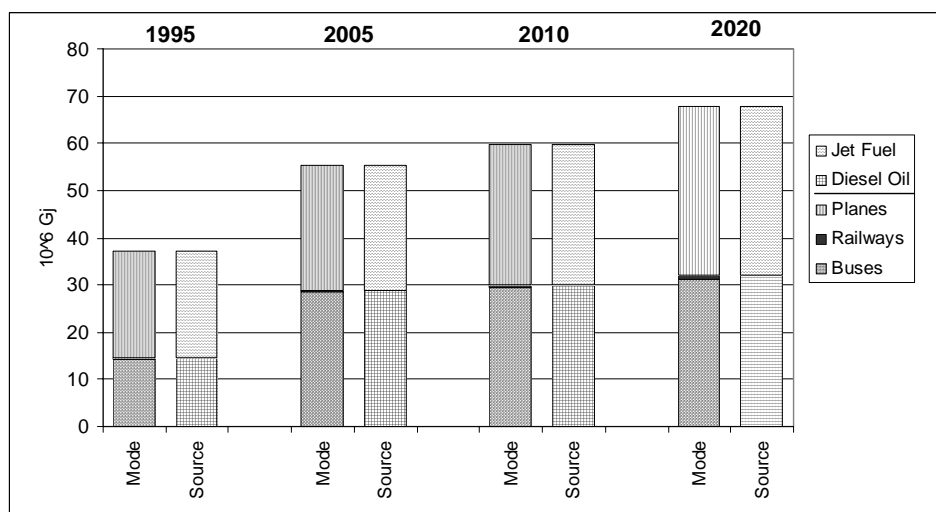
Three modes have been considered: Interurban buses, Railways, and Aeroplanes. As from the transport sector restructuring the interurban railway passenger service was almost interrupted and the more profitable urban railway lanes were licensed to private agents, accounting for less than 1% of to the subsector's energy consumption in the base year.

Even when railway is expected to gain certain share in service supply, it will only contribute slightly over 1% to the subsector's energy consumption in the future. Consequently, road and air passenger transportation will account for 99% of total energy consumption. JP will maintain its predominant position, although its share decreases from 61% in 1995 to 53% in 2020. Meanwhile, diesel oil will account for 47%, increasing by eight points its 1995 percentage.

Freight transportation

Freight transportation accounts for almost 60% of sectoral consumption, with a growing trend that shall increase its share to over 63% in 2020. The expected average growth rate amounts to 4% per annum, i.e. two percentage points lower than that observed in the recent past. Growth rates have been assumed variable for different periods, with an important acceleration in the 2010/2020 decade (7% annually), because of the above mentioned reasons.

With 825.7 million Gigajoules consumption in 2020, the subsector accounts for over 88% of the sector's diesel oil consumption and 59% of such fuel's total consumption in the country. The remaining fuels used are gasoline, CNG, fuel oil, electricity, and hydrogen.

The transportation modes considered are Trucks, Railways, and River and Sea Shipping. Heavy duty Trucks hold a significant role in the subsector's consumption as, in spite of losing share, it accounts for 54% of the subsector's energy consumption in 2020. Light and heavy-duty trucks contribute over 98% of energy consumption in 2020, a percentage similar to that of the base year.

Diesel oil retains its major role, and without any substantial switching between modes, the only elements to be highlighted are CNG penetration —22.7% of consumption in

125

2020— and the introductory emergence of hydrogen in light duty trucks. CNG has a highly relevant penetration, growing at an average rate over 11% per annum during the whole period and at a higher pace between 2010 and 2020. Gasoline exhibit a clear regressive trend, being replaced by CNG its share is very minor in 2020.

Figure 23   Consumption by source and mode
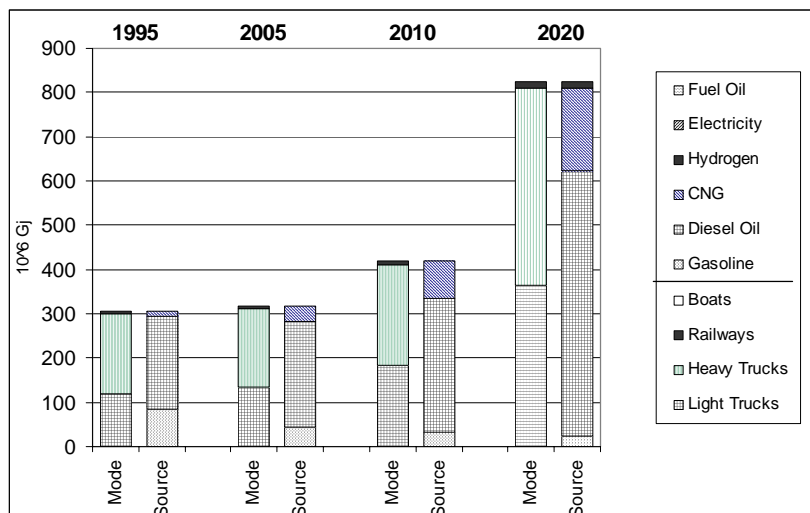
As for the role of sources within each transportation mode, the most remarkable features are as follows. Gasoline shall disappear in heavy-duty trucks. Fuel oil shall still be used in the shipping mode but having a low share (0.13% of the subsector's consumption). Energy consumption by light duty trucks will suffer major changes allowing for a higher source diversification of total subsectoral energy consumption due to its growing share. The first hydrogen fuelled and electric vehicles shall be in use in 2020, anyway hydrogen will account for only 1.6% of consumption and electricity for 0.1%.

The subsector shall still rely on non-renewable sources; petroleum products still prevail; gas penetration permits a certain degree of diversification and involves a positive effect on the subsector's specific emissions. The effects of such results on emissions shall be discussed under the specific heading.

2.5   Agriculture and cattle-raising, silviculture and fishing sector

The agriculture and cattle-raising sector has a limited share in energy consumption (slightly above 6% of Final Consumption), although significantly mounting in the 1980-1995 period (3.9% annually), reaching 107.61 million Gigajoules in 1995 according to the Energy Balance data.

As for the structure by source, consumption comprises three sources: electricity, diesel oil, and biomass, albeit extremely concentrated in diesel oil (over 97% of the total). The structure exhibits a certain stability, although a gradual penetration of biomass seems to be noted and, electricity to a lower extent.

To extrapolate historic trends, the activity level accounted for by the sector's added value was used as explanatory variable, assuming a gradual decrease of energy intensity. Considering the year 1995 as value 100, energy intensity would drop to 86.5 in 2020.

As detailed when describing the socio-economic scenario, this sector is expected to grow significantly in the long term, the added value growth rate shall be 5.5% annually for the 1995-2020 period, resulting in a growth rate of 4.85% per annum for energy consumption.

Bearing in mind that the food industry had been assumed as one of the major growth sectors and dairy products shall be one of the most dynamic branches, important growth should be expected in the related primary sector, among others, dairy production (dairy farming). Consequently, higher electricity penetration is estimated, mainly based on growing milk production mechanisation. Doubling its share (1.5% in 1995 vs. 3.0% in 2020 represented such electricity penetration in mechanical uses). The role of biomass shall also grow, although not as fast as electricity.

As a result of the hypotheses assumed and the explanatory variable behaviour, the sector's total energy consumption and its structure by source reach the values illustrated in Table 23.

Table 23   Energy consumption in agriculture, cattle raising, silviculture and fishing sector

Source	1995		2005		2010		2020	
	Mill.GJ	%	Mill.GJ	%	Mill.GJ	%	Mill.GJ	%
Electricity	1.63	1.5	3.21	2.0	5.58	2.5	10.55	3.0
Diesel oil	104.89	97.5	155.52	96.8	214.57	96.1	335.95	95.5
Biomass	1.09	1.0	1.93	1.2	3.13	1.4	5.28	1.5
TOTAL	107.61	100.0	160.66	100.0	223.27	100.0	351.78	100.0

This sector is one of those evidencing the highest growth (227% for the 1995/2020 period), equivalent to an average annual rate of 4.85%. Electricity, in turn, grows at a 7.7% annually, diesel oil at 4.8% per annum and biomass at 6.5% annually

2.6   Industrial sector

2.6.1 General considerations

The 1994 Economic Census (1994-EC) data reported the following sectoral structure:

Table 24   Industrial structure

Industrial branch	Percentage
Foods, beverages and tobacco	25.4
Textile, garments and leather	11.3
Timber, paper and printing	13.8
Chemical and petroleum products	6.2
Non-metal mineral products	4.6
Metal and metal products manufacturing	15.1
Transportation equipment and parts manufacturing	3.6
Machinery and equipment production	20.0
Total number of shops	96.377

Such census illustrates an increase in industrial concentration, businesses with over 200 employees amounted only to 632 in the 1994 census, while in 1985 there were 918 and 1031 in 1974.

The 632 industries surveyed by the 1994-EC accounted for only 0.7% of the total facilities and employed around 300.000 workers (28.5% of the total). The small and medium-sized

enterprises (SMSs), hiring less than 50 employees each, amounted to 93,154 in 1994 vs. 105,215 in 1985.

After 1991, an important capital investment process has taken place, which can be measured by a number of indicators allowing to classify industries in: natural resources intensive (NRIA); capital intensive (CIA); qualified labour intensive (qLIA) and non-qualified (nqLIA).

Almost all manufacturing branches are today more capital-intensive than in the past; those who already were capital intensive in 1990 increased the use of such factor and those being labour intensive in 1996 were even more so in 1990.

Capital-intensive branches gained share in value added in manufacturing, jobs and exports. In such sense, the CIA branches accounted for 36% of the value added in manufacture in 1991 and 44% in 1996; 22% of the industrial jobs in 1991 and 28% in 1996.

This change is a consequence of the industrial restructuring in Argentina. Transportation materials manufacturing and electric machinery; appliances and supplies give a clear example of these movements. Such branches have changed their techniques becoming capital-intensive activities whereas in 1990 such industries were labour intensive.

A more detailed analysis permits to state that the gain in share by capital intensive branches is defining the industry's behaviour as a whole. Also, such branches' expansion shall favour higher industrial exports. This transformation process shall have long-term consequences. It responds to the new macroeconomic conditions (opening, relative prices, price stability) and the need for higher competitiveness and better international insertion.

It should be pointed out that capital intensive branches accounted for 74% of the 1996 industrial production, whereas such group contributed only 32% in 1984.

The average value added per worker increased 57% in the 1990/96 period and it can be proven that such increase is not only due to a drop in the number of workers.

Finally, it should be pointed out that attractiveness of foreign markets in the last years has generated a continuous increase in the number of exporting companies, from 6,500 in 1988 to 8,100 in 1992, exceeding 11,000 companies in 1996. Such growth (92-96 period) was mainly due to small exporters whose insertion used to be very low in the past. Such process defines a certain diversification of exports, although exported volume is still highly concentrated in a small number of companies.

The five major exporting branches —oil companies, vegetable oils and cereals— account for about 17% of total exports, while companies exporting under US$ 50 million a year generate slightly over 40% of the foreign sales.

Summarising, even when the manufacturing industry has lost GDP share, a significant transformation has taken place permitting the prevailing sectors to become strong and dynamic.

2.6.2 Energy consumption

The sector's final energy consumption amounted to 27.8% of the total, according to the 1995 National Energy Balance. Such share had amounted to 28.1% in 1990. Energy consumption growth in the 90/95 period was 28.4%, equivalent to 5.12% per annum.

Table 25 shows energy consumption by primary and secondary sources for years 90 and 95 as recorded by National Energy Balance.

128

Table 25   Energy consumption by sources in the industrial sector (10^6 GJ)

PRIMARY SOURCES		1990	1995
Coal		0.25	1.26
Firewood			1.88
Bagasse		18.00	27.09
Other primary sources		27.42	46.09
	Subtotal	45.67	78.32
SECONDARY SOURCES			
Electricity		76.98	92.39
Distributed gas		173.97	236.84
LPG		1.00	2.30
Diesel oil		3.64	5.82
Fuel oil		15.91	14.27
Petroleum coke		6.70	14.86
Coke-oven gas		4.94	3.27
Blast-furnace gas		4.98	2.22
Coke		5.69	1.30
Non-energy products		18.84	8.41
	Subtotal	312.65	381.68
TOTAL PRIMARY+ SECONDARY		358.32	460.00

Source: Energy and Ports Secretariat

Analysing the structure by source for the reference years, it can be seen that in 1990, electricity's share was 21.5%, distributed gas 48.6%, and biomass 12.7%, while in 1995 such shares changed to 20.1%, 51.5%, and 16.8%, respectively. In the last five-year period, electricity's share decreased by 6.5% while distributed gas increased its share by 6% and biomass by 32% (mainly wastes from vegetable oil manufacturing).

The steady growth in distributed gas share (3.8% per annum since 1986) and biomass (4.6% annually) should be highlighted. Fuel oil and non-energy products account for the major decreases. Electricity grew at 2.8% annually since 1985, however its share in the 1995 consumption drops due to the higher growth of gas and biomass consumption.

The above mentioned electricity consumption includes both grid electricity and self-produced. Distributed gas penetration shall grow as the gas supply network covers the whole country.

2.6.3 Splitting by modules

According to a number of criteria to be discussed when analysing mitigation options, the industrial sector's consumption were split in branches as indicated in Table 26

The selected modules bear the following characteristics:

1. Selected activities are within the 16 branches that jointly account for over 78% of the energy consumption from the 72 surveyed branches.

2. The selected energy intensive activities (cement and pulp & paper) rank first and fourth in energy incidence, measured by the incidence of energy bill on total cost.

3. The manufacturing of cellulose pulp and paper enjoys excellent development perspectives, mainly because of the high yields in implanted forests, above most of the countries devoting to forestry.

4. Cement, lime and gypsum production shall meet growing local demand, both for the construction of housing and infrastructure works, absolutely necessary in a country with a vast territory as Argentina.

5. Meatpacking plants face excellent export perspectives, just like vegetable oils and dairy products.

6. The textile industry shall be restructured —expanding and streamlining their plants—, for which broad experience exists in the country.

7. A large number of companies from all the sectors selected are fitted with technologies comparable to the highest international level. The greatest lags appear in the textile industry and, to a lower extent, in meatpacking plants with the exception of integrated plants.

8. The most technologically outdated firms in each branch shall have to streamline or disappear during the period under analysis.

9. It should also be borne in mind that towards the year 2010 /2020, the completion of existing facilities' useful life and the need for larger installed capacity shall result in substantial capacity expansion.

Table 26   Branches selected and their characteristics

ISIC	BRANCH	10^6 GJ	% Total Energy	% Energy Incidence
	ENERGY INTENSIVE	268.88	58.43	
21010	Pulp & paper	32.99	7.17	11.57
2694[a]	Cement, lime and gypsum	38.76	8.42	17.27
	Others (*)	197.13	42.84	
	NON ENERGY-INTENSIVE	191.16	41.57	
15111	Meatpacking plants	10.67	2.32	1.92
15140	Vegetable oils	29.66	6.45	2.23
15200	Dairy products	8.30	1.80	1.90
171AA	Textiles	13.19	2.87	4.71
	Others (**)	129.34	28.13	
	TOTAL	460.04	100.00	2.69

Notes: Others (*) comprises the following energy intensive branches
      15420 Sugar
      2411A Chemical industry
      24130 Plastics
      2610[a] Glass containers
      269AA Ceramics
      27100 Steel and iron
      2720A Aluminium
Others (**) comprises any manufacturing branches not included in any other module.

2.6.4 Energy consumption by selected module

Pulp and paper manufacturing

In the base year, the sector's total energy consumption ranked fourth with 32.99 million GJ. Its share in the manufacturing sector's total energy consumption was 7.17%.

Biomass was the energy product with the highest share in energy consumption, 53.7%. This illustrates the effective use of agroindustrial wastes as Black Liquor, a strongly polluting agent an extra reason to promote its use as energy product.

Distributed gas ranked second with 28.8%. Grid electricity had 6.1% penetration and self-produced electricity 4.4%. It should be pointed out that the production processes used favour cogeneration to meet steam and electricity requirements.

Energy bill accounts for 11.57% of total costs, also ranking fourth in energy incidence.

Cement, lime, and gypsum production

The final energy consumption in this branch reached 38.76 million GJ in 1995. This figure accounts for 8.42% of total consumption by manufacturing, ranking third as regards energy consumption.

The main energy source was distributed gas, accounting for 89.1% in 1995. The share of grid electricity reached 9.3% and a tight 0.7% for self-production.

Energy costs' impact was 17.27%, one of the highest in all the manufacturing industry.

Cattle slaughterhouses and meatpacking plants

This branch's final energy consumption amounted to 10.67 million GJ in 1995, accounting for 2.32% of the manufacturing industry's total consumption. Specific consumption amounted to 3.56 MJ/Ton of beef. The specialised bibliography presents specific consumption of about 5 MJ/Ton of beef equivalent with bone for technologically advanced meatpacking plants.

Distributed gas supplied 63.5% of total consumption, electricity follows with 19.5% (including 0.7% of self-production), a high share due to its use in preservation by low-temperature and cold storage of meat. Fuel oil still accounted for 12.5% and diesel oil 3.5%. Other sources, such as biomass or LPG, account for a marginal share.

Because of its total energy consumption, its percent share in total industrial consumption, the value of energy incidence (1.92%) and the huge opportunities for technological and process improvements detected in the diagnosis, this module justifies its selection for the mitigation analysis.

Vegetable oils and fats

In 1995, such activity's energy consumption reached 29.66 million GJ, i.e. 6.45% of the whole manufacturing sector's consumption. Due to its relevant energy consumption, the vegetable-oil industry ranks fifth among all activities, its energy incidence recorded being 2.23%.

Prevailing energy sources are biomass (45.26%) and distributed gas (41.62%).

Dairy products

This branch used 8.3 million GJ in 1995, i.e. 1.8% consumption share. The energy incidence (1994) amounted to 1.9%; energy intensity decreased from 117.6 KJ/$ 1986 in 1990 to 105.91 KJ/$ 1986 in 1995.

Specific consumption, related to tons of fluid milk and products' mix, was 2.89 MJ/Ton in 1986, a value which was already lower than the 4.02 MJ/Ton considered as the international standard. In 1995, specific consumption amounted to 2.93 MJ/Ton of product.

Distributed gas was the major energy source with 44.3% share. Fuel oil follows, with 27.7%, attributable only to the fact that gas had not reached all industrial facilities.

Electricity also evidences a substantial share of 22.3% (including 0.6% self-production), originating in the use of pumps and preservation by low temperature and cold storage of its products.

Textile fibres, yarn, fabrics, finishing of textile products

In 1990, the activity used 10.15 million GJ (2.8% of the manufacturing total); the energy incidence in total cost was 4.71%. In 1995, the former changed to 13.19 million GJ (2.9% of the manufacturing total).

Specific energy consumption ranged between:

1. cotton yarn and fabrics   41. 43 GJ/Ton of fibre in spinning mills

2. woollen yarns and fabrics   31. 23 GJ/Ton of unwashed wool

(In the case of cotton, Tons express fibre consumption in spinning mills, whereas in the case of wool same account for unwashed wool).

It should be pointed out that synthetic fibre yarns and fabrics involve a much higher specific consumption.

Specific consumption in Argentina may seem lower than in Colombia or the U.S. because only natural fibres are being considered. Had synthetic fibre manufacturing been included, figures would have been larger.

As for the structure by energy source, electricity accounted for about 30% in average, and distributed gas for 68.5% in 1995.

Remaining industries

The branches excluded from the above items involve energy intensive and non energy-intensive activities. Among the first, seven of them account for 43% of the final energy consumption by manufacturing, i.e.: steel and iron, aluminium and non-ferrous metals, petrochemicals, plastics, sugar, glass and ceramic containers, accounting for a total demand of 197.13 million GJ.

Steel and iron, and aluminium are in line with the best international standards regarding technology. Only the plants' scale could be improved seeking enhanced performances. However, in the steel and iron industry, the coke production efficiency could be increased and continuous casting adopted for all the plants.

Capacity increases are assumed to comply with the highest technological levels, and insofar the market permits, with production scales suitable to the competitiveness sought.

Other activities such as the sugar industry offer better improvement opportunities, especially in the short and medium term. The interest in materialising such improvement as mitigation options is however relative, as cane bagasse, i.e. biomass, is the major energy source used in this industry.

Anyway, and from the technical standpoint, it was estimated that energy intensity could improve by about 12% in average for these energy-intensive manufacturing branches.

As for other non energy-intensive industries, which as already stated involves 59 activities, same account for only 28.12% of the manufacturing sector's final energy demand (129.34 million GJ).

This group includes the most energy inefficient industries. All known RUE measures can be applied, e.g. optimising the use of boilers, enhancement of burners, using economisers, steam and condensed water recovery, improve machine and equipment maintenance and insulation, process automation, sources substitution, use of biomass, recycling, heat and electricity cogeneration, among others.

As for new capacity, it is assumed that the latest international market advances shall be employed.

Taking into account the historic trend of average specific consumption and the opportunities to achieve better performance, it was estimated that energy intensity could drop some 12% by technical improvement.

2.6.5 Scenario assumptions

Among all potential explanatory variables the value added appeared to fit better energy consumption movements. According to the socio-economic scenario, the value added in manufacturing (VAM) is expected to grow at the following annual rates:

Table 27   Expected grow rates for VAM

Period	Annual rate
1995/2005	3.82 %
2005/2010	5.00 %
2010/2020	5.20 %

According to the hypotheses described in the Introduction, energy intensities have been assumed to decrease at 0.55% per annum between 1995 and 2020. However, the average energy intensity in manufacturing will be also affected by movements in the VAM structure, particularly when they involve changes in energy-intensive activities' share.

Such hypothesis is based on different assumptions, among which the following should be mentioned:

- Capital renewal, incorporating higher efficiency equipment.
- Installed capacity increase incorporating state-of-the-art equipment, driven by the effective demand of goods produced by each branch.
- Changes in production processes, improving the efficiency in the use of raw materials, production inputs, and factors, including energy, especially in those activities subjected to international competition.
- Partial equipment renewal (electric engines and boilers, among others), improving processes' thermal and mechanical efficiency.

As a consequence, the following average energy intensity and elasticity result:

Table 28   Average elasticity and energy intensity

Average Elasticity		Average Energy Intensity	
Period	Energy/VAM	Year	GJ/1000 US$
1995/2005	0.862	2005	0.86
2005/2010	0.911	2010	0.89
2010/2020	0.867	2020	0.88

2.6.6 Results for the baseline scenario

The energy consumption projections are aggregately presented for energy intensive and non energy-intensive activities.
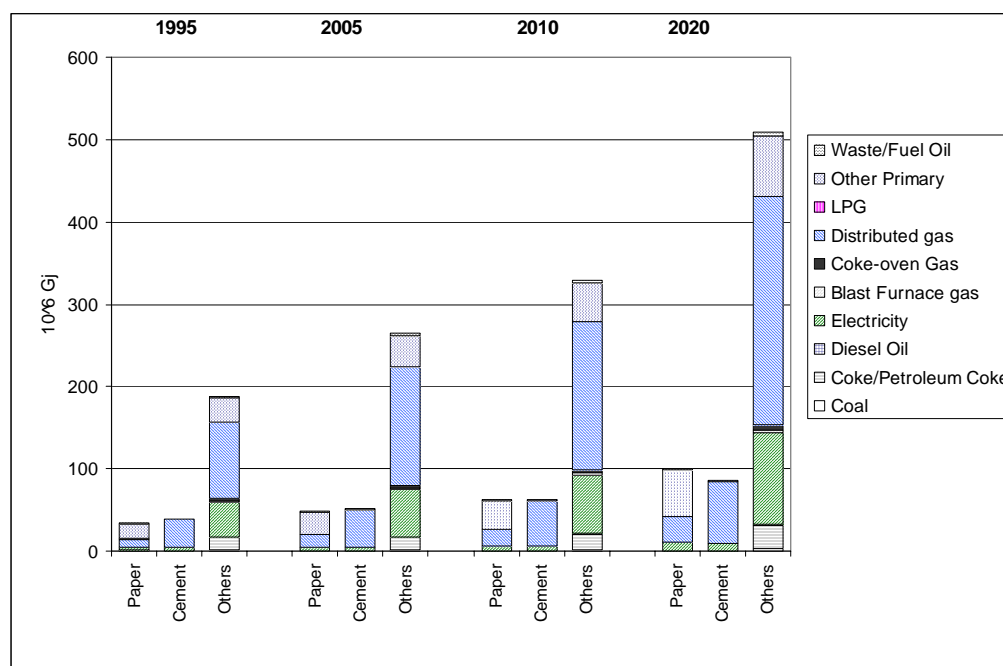
Energy intensive activities used 269 million GJ in 1995 and shall use 712 in the year 2020. Such consumption's evolution, and the respective growth rates, are summarised below:

Table 29   Energy-intensive activities. Baseline scenario
Energy consumption and growth rates

	Unit	1995	2005	2010	2020	1995/2020
Energy consumption	Mill GJ	268.88	372.2	463.69	711.70	
Average annual rate	%		3.31	4.49	4.38	3.98

Sources' importance in each milestone year is shown in Figure 24 where biomass' (other primary sources) share grows between 1995 and 2020 by 0.6 points, grid and self-produced electricity maintain their share and distributed gas penetration grows by 3.6 points.

Figure 24   Energy-intensive activities. Consumption by branch and source

As for non energy-intensive activities, results read as follows :

Table 30   Non energy-intensive activities, baseline scenario
*Energy consumption and growth rates*

	Unit	1995	2005	2010	2020	1995/2020
Energy consumption	Mill GJ	191.18	264.12	331.35	523.57	
Average annual rate	%		3.28	4.63	4.68	4.11

In the 1995/2020 period, biomass increases its share by 1%, grid electricity, 1.3%, and distributed gas, 1.42%.

Fuel oil starts regressing, its share drops from 5.1 to 2.9% and diesel oil's from 2.75 to 2.02%, both sources replaced in thermal uses by biomass and distributed gas.

Energy consumption growth is slightly higher than in energy-intensive activities, in part due to a slightly higher growth in value added for non energy-intensive activities and also to the lower efficiency of the equipment installed in this type of activity compared to those in the energy-intensive group.

Figure 25   Non energy-intensive activities. Consumption by branch and source
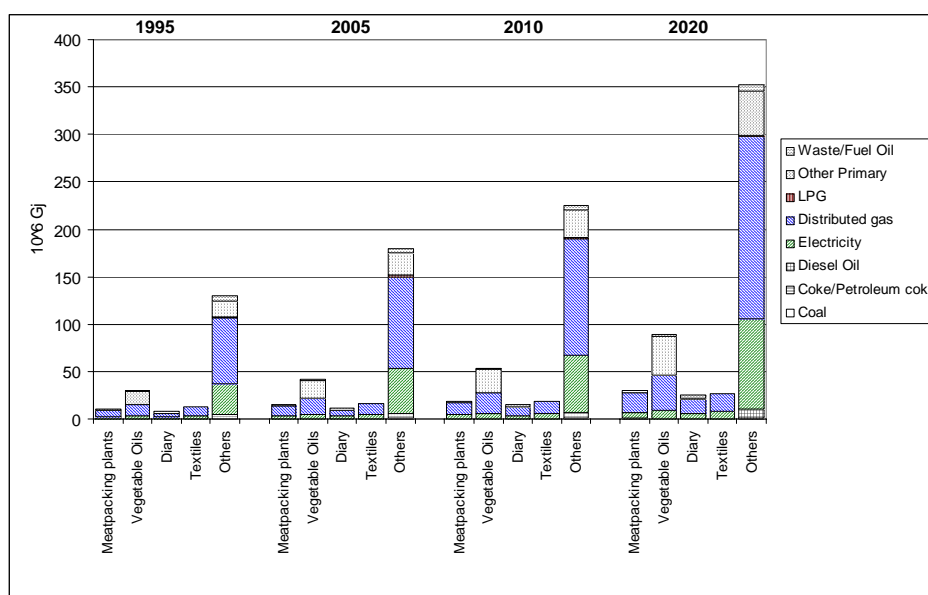
As a result of the evolution expected, non energy-intensive industry increases its share, accounting for 42.4% of sectoral consumption in the year 2020 vs. 41.6% in the base year.

2.7   Non-energy sector

The non-energy sector's share in the Argentine Energy Balance is similar to the commercial and public, and agricultural and cattle-raising sectors, evidencing a very low average annual growth rate -under 1%- in the 1980-1995 period. However, a very substantial growth rate is attained (6.4%) as of 1990, after reaching a very low level that year.

As for the structure by source, consumption is extremely concentrated in non-energy products, gasoline and LPG, which jointly account for over 90% consumption. LPG is the most dynamic source; its share has systematically grown (9% in 1980, 17% in 1996) to the detriment of the remaining sources.

The remaining sources used in the sector are distributed and refinery gas —which never exceeded a joint share of 10%—.

The projection was made following the trend, with certain autonomy, using the petrochemical industry's expected growth as the reference rate.

It has been assumed that no difference will exist between the values projected for both scenarios, and also that the structure by source remains constant, concentrating in distributed gas, gasoline, LPG, and non-energy products.

As a result of the hypotheses assumed and the explanatory variables' behaviour, the sector's total energy consumption and each source share exhibit the values appearing in Table 31.

Table 31   Energy consumption by the non-energy sector

Source	1995	2005	2010	2020
Distributed gas	9.13	13.29	16.99	27.02
LPG	18.46	26.88	34.37	54.66
Gasoline	24.78	36.08	46.14	73.38
Non-energy product	47.85	69.66	89.08	141.67
TOTAL	100.21	145.91	186.57	296.73

The values appearing in the preceding table evidence a 4.4% average annual growth rate for total consumption in the 1995-2020 period. Until the year 2005, the rate amounts to 3.8% per annum, in the 2005/2010 period 5% annually, and in the last decade, 4.7% per annum. The magnitude of total consumption is 196% higher in 2020 compared to 1995 values.

The structure by source, assumed as remaining constant, will be as follows; natural gas 9.1%, LPG 18.4%, gasoline 24.7%, and non-energy products, 47.8%.

2.8   Self-consumption

The evolution of energy self-consumption is directly linked to the supply system's activity and to the role played by the different sources. As for its absolute magnitude, the self-consumption ranks fourth, preceded by transport, industry, and residential sectors, practically doubling however the annual consumption of sectors such as commerce and public, and agriculture and cattle raising. As for the structure by source, consumption is extremely concentrated in natural gas, refinery gas, and fuel oil, followed by electricity and diesel oil and, as primary source, coal. Distributed gas is the most dynamic source, its share has systematically increased, reaching over 70% in 1995/6.

This sector's demand is driven by the final energy demand. Projections were made relating each source's self-consumption to its own demand, with the exception of electricity, basically used by the hydrocarbon industry. Consequently, electricity self-consumption relies on the oil industry's activity level, as for the sake of this study the electricity used in power plants was excluded by considering net electricity supply.

As a result of the hypotheses assumed and final energy demand's behaviour, the sector total energy consumption and its structure by source reach the values appearing in Table 32.

The values appearing in the above table mean a 3.5% average annual growth rate for total consumption in the period 1995-2020. Until the year 2005, the average rate is 2.0%, in 2005/2010, 5%, and in the last decade, 4.2%. Self-consumption would be 136% higher in 2020 than in 1995.

Table 32   Energy self-consumption

Source	1995		2005		2010		2020	
	Mill GJ	%	Mill GJ	%	Mill GJ	%	Mill GJ	%
Coal	1.01	0.60	1.40	0.6	1.70	0.6	2.60	0.6
Electricity	1.55	0.08	2.18	1.0	2.70	1.0	4.06	0.9
Distributed gas	126.63	69.90	159.37	71.6	207.67	73.1	320.70	74.6
Refinery gas	21.27	11.70	36.76	16.5	44.51	15.7	60.00	14.0
Diesel oil	4.90	2.70	4.99	2.2	6.42	2.3	10.89	2.5
Fuel oil	22.65	12.40	13.71	6.2	15.84	5.6	23.87	5.5
Petroleum coke	4.23	2.30	3.41	1.5	4.25	1.5	6.57	1.5
Non-energy product	0.25	0.10	0.69	0.3	0.89	0.3	1.41	0.3
TOTAL	182.47	100.00	222.51	100.0	283.98	100.0	430.10	100.0

2.9   Aggregate results

As a result of the analyses made for each consumption sector and the general hypotheses assumed for the socio-economic scenario, the total final demand was obtained for 2005, 2010, and 2020, i.e. the milestone years defined (Table 33).

Table 33   Total final consumption

Source	1995		2005		2010		2020	
	Mill GJ	%	Mill GJ	%	Mill GJ	%	Mill GJ	%
Hydrogen							16.59	0.4
Biomass & Other Primary	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
LPG	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 products	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

From the above results, the following could be remarked:

• The average annual growth rate for the whole period (1995/2020) amounts to 3.8%.

• The growth rates by subperiod are:

1995/2005	2005/2010	2010/2020
2.9%	4.7%	4.3%

• Energy productivity, measured on final consumption (GDP/Final Consumption) evolves and reaches the values shown below (in 1994 dollars per Gigajoules). This means that a 14% improvement is visualised for 2020, compared to 1995 values.

| 1995	2005	2010	2020
149.3	166.4	168.4	170.5

- Total final consumption increases by the following percentages with respect to base year values:

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

As for the analysis by source, the following aspects should be highlighted:

- Distributed gas' growth, becoming the major source; petroleum products, LPG, and other gases loss of ground, and electricity share growth.
- A "less emitting" final consumption structure appears in 2020, due to the decrease in share of the highest emitting sources and the slight growth of zero emission sources (hydrogen and biomass).

*Figure 26   Final consumption by source*
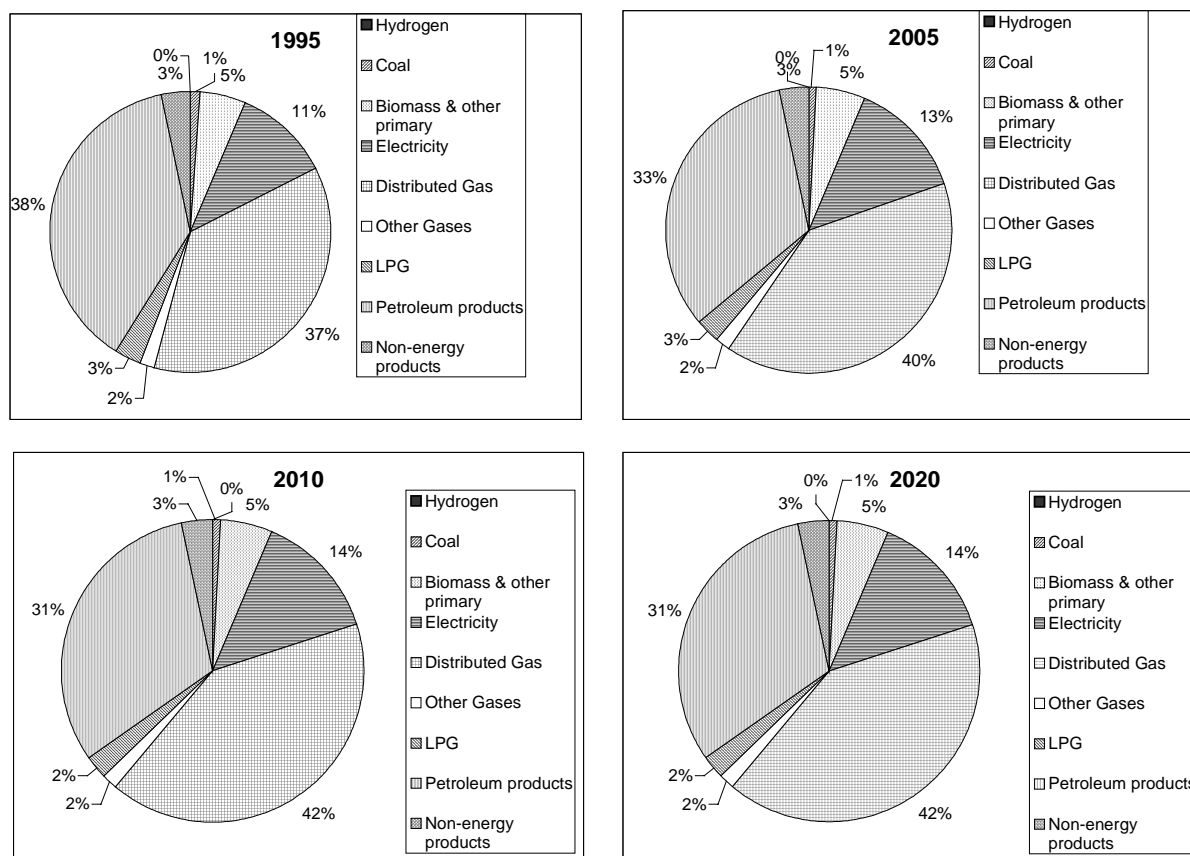
As for different sectors' share, it should be pointed out that:

- The most dynamic sector is agriculture, silviculture, and fishery, increasing its share by 1.63 points (27%) in 2020 compared to the base year.
- The industrial sector's relative importance increases by 1.16 points (4.5%) in 2020.

- The residential, commercial and public, and self-consumption sectors lose share.
- The transport sector decreases its share very slightly, with a percentage above 28% it still remains the highest final consumption sector.

Figure 27   Final consumption by sector
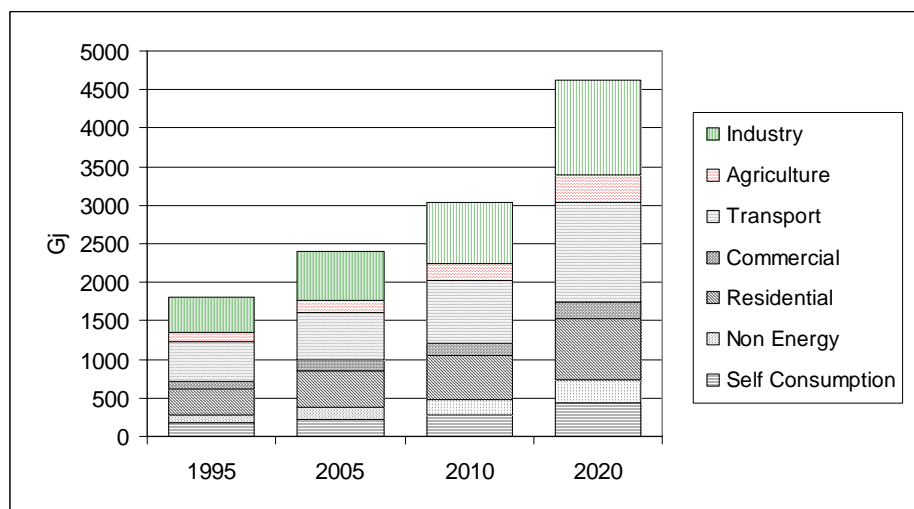
3 Energy supply in the baseline scenario

The main features of energy supply are presented herein, should the context defined in Section 1 above materialise and final consumption behaviour be as described in Section 2. To facilitate the interpretation of results, the following paragraphs analyse each of the energy industries' evolution separately and, finally, some comments are made about the use of primary energy sources and the system's global efficiency.

3.1   The electricity industry

As seen in the previous section, domestic electricity consumption is expected to grow steadily, at 5% average annual rate, until the year 2010, and at a pace slightly above 4% a year after that date. From the standpoint of local generation, the foreign trade of electricity that appears in Table 34 should be added to domestic consumption.

Table 34   Electricity requirements

		1995	2005	2010	2020
Final consumption	PJ	200.92	324.04	416.39	634.26
Annual rate	Subperiod (%)		4.9	5.1	4.3
	Accrued (%)		4.9	5.0	4.7
Imports		8.43	34.54	34.54	34.54
Exports	PJ	0.81	30.43	45.15	73.95
Net Balance		-7.62	-4.10	10.61	39.41
Total requirement		193.30	319.94	427.00	673.67
Annual rate	Subperiod (%)		5.2	5.9	4.7
	Accrued (%)		5.2	5.4	5.1

The above recorded electricity imports accounts for the binational hydropower station's portion (shared with Paraguay) geared to the Argentine market exceeding the 50% that corresponds to Argentina. Exports should be interpreted as exports net of contingent imports. As seen, generators' dynamics in exporting electricity shall increase the need to expand local supply to about 6% annually until the year 2010.

Approximately 6% of such requirements will be met with self-production in the industrial and mining sectors. Such values would imply a slightly lower self-production share than in the base year (8%), as the context assumed for the electricity public supply (abundant supply and competitive prices) shall discourage self-production, restricting it to strictly justifiable amounts in terms of waste use or activities far from the grids.

Self-production was analysed together with final demand, in order to tie its growth to the evolution of productive activities where such generation occurs, and to adequately reflect the type of fuel to be burnt. According to the results obtained, fuels used in self-production would grow at a pace equivalent to an average annual rate close to 2% throughout the period under analysis. Fossil fuels would maintain a share close to 90%, although natural gas use would increase going from 61% in the base year to 65% in 2020.

Electricity production in public service power stations shall follow the growth of electricity demand albeit at a slower pace in the next decade thanks to the reduction assumed in transmission and distribution losses. Thus, while requirements would increase by 69% between 1995 and 2005, electricity generation should only increase 54% in the same period.

In spite of such efficiency increase, which will surely be approached by distributors, generators' dynamics implies incorporating until the year 2005 8,100 MW to the capacity installed in 1995. This amount includes 5,700 MW in thermal power stations, 1,700 MW in hydropower stations, and 700 MW from a third nuclear power station to be finished then. Thus, reserve percentages in the year 2005 are expected to be high in terms of the system's peak load.

Only after that year was it assumed that expansion would adjust to electricity demand evolution. This hypothesis is based on the fact that new investments will be defined considering that the new power stations shall compete in the market with high efficiency ones and, therefore, investors will be more cautious than at the time when the existing installed capacity was renewed.

In spite of this, between years 2005 and 2020, 19,300 MW should be incorporated to the service to meet growth in demand and to replace about 1,700 MW of existing equipment at the end of their useful life.

The assumed strategy for electricity generators to privilege the installation of high-efficiency combined cycles above any other technology shall imply a substantial change in the electricity public service generation structure.

As seen in Figure 28, the freezing of hydroelectric and nuclear supply after the year 2005 notably limits their share in total generation, which drops from 55% in the base year to only 22% in the horizon year.

Thus, fossil-fuelled thermal power stations would have to supply the additional demand, increasing their share in total generation at a clearly faster pace after the year 2005 to reach 78% by the end of the period compared to 45% in the base year. Combined cycle power stations would contribute 90% of total generation from conventional thermal

power stations in the year 2020, whereas in 1995 such power stations were practically non-existent (2%).

Figure 28   Generation by generating technology
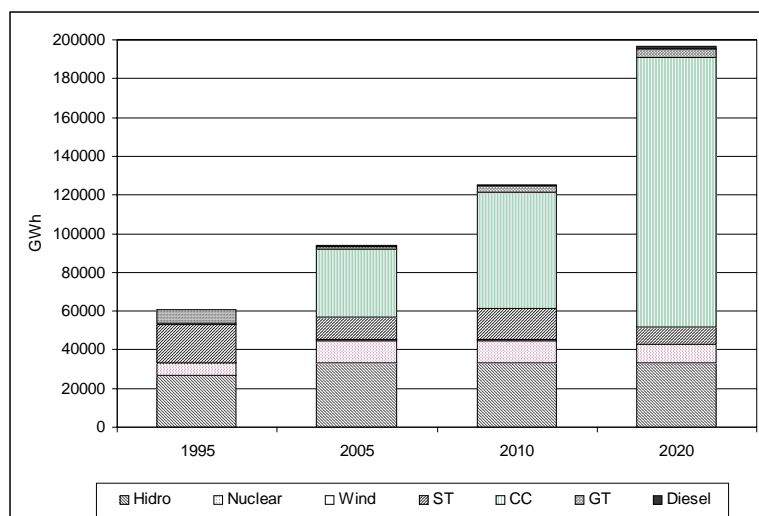
It should be remarked that the percentages showed in Figure 28 correspond to "local" generation. That is, taking 50% of Yacyretá hydropower station generation as own and the remaining 50% as electricity imports. If this power station's total contribution were considered as own, as does the agency in charge of the load dispatching, the hydroelectric share would grow to 20% in the year 2020, compared to the 16% appearing in said figure.

Changes in generation mix shall impact the volume and type of energy sources used by power stations. Regarding the structure by source and as seen in Figure 29, as of year 2005 fossil fuels share will grow and reach 82% of total power stations' inputs in the year 2020.

Figure 29   Input structure in power stations
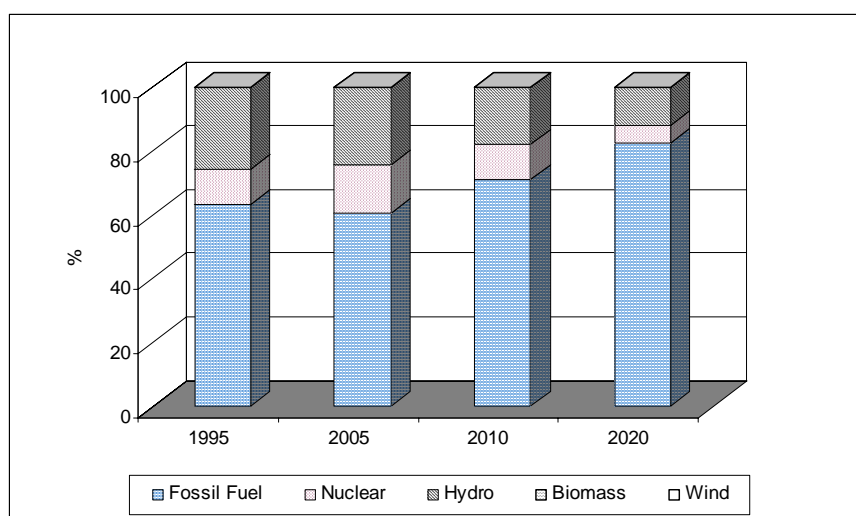
Among fossil fuels, natural gas shall have a growing share, accounting for 93% of the total fossil fuels burnt in public service power stations in the year 2020, as results from

Figure 30. The expected expansion in the use of gas, equivalent to 5.5% average annual rate during the next 25 years, should have substantial impact on the gas industry, as discussed in the next paragraph.

Figure 30   Fossil fuels burnt in public service power stations
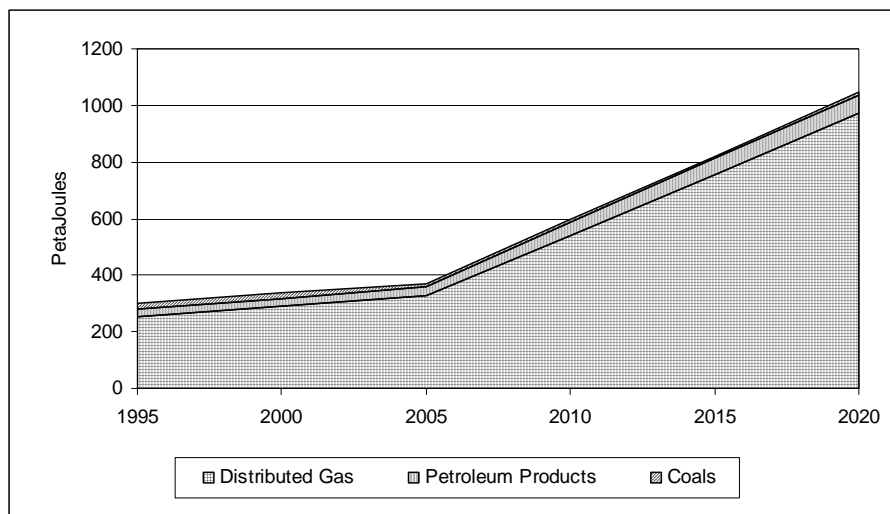
However, such gas demand growth in power stations shall not be even throughout the period, as until 2005 the incorporation of hydroelectric and nuclear power stations that are presently under construction shall reduce the production increase in fossil-fuelled thermal power stations. After 2005, power stations' gas demand is expected to grow at 7.5% average annual rate until the horizon year. Future evolution of petroleum products' consumption will highly rely on gas availability. As long as gas production expands at the required pace, power stations will burn very few liquid fuels (around 6% of fossil fuels).

The future increase in power stations' gas demand, irrespective of how substantial it may seem, has been slowed however, by the increase assumed in thermal power stations' efficiency. In effect, the incorporation of state-of-the-art combined cycles will permit an increase in conventional thermal power stations' average performance from 33% in 1995 to 53% in the year 2020. Had this remarkable growth in thermal efficiency not been assumed, fossil fuel consumption would have been 60% higher than expected.

As seen below, this hypothesis would have two types of effects. In the first place, it helps render viable an energy system development based on the intensive use of gas, decreasing pressure on natural gas reserves. Secondly, it permits to mitigate GHG emissions' growth, which would otherwise augment the consequences of energy consumption's sustained growth in the country.

3.2   The gas industry

According to the forecasts made, whose results appear in Table 35, domestic gas demand would grow in the baseline scenario at a pace equivalent to about 5% average annual rate throughout the next 25 years, with an even steeper expansion after the year 2005.

When presenting gas demand, categories normally used by gas distributors have been reflected. Thus, industrial consumption includes both the energy consumption and gas used by the industry with non-energy purposes. The sole exception are electricity power

stations, where consumption include the gas burnt in self-production power stations, normally recorded by gas companies as part of industrial consumption.

Table 35   Natural gas demand in the baseline scenario

		1995	2005	2010	2020
Residential/comm.		253.13	351.70	417.67	571.41
Industrial		245.99	359.14	450.71	695.98
Transportation	PJ	35.01	86.00	170.05	336.10
Power stations		284.41	359.69	579.06	1026.48
Total domestic demand		818.54	1156.53	1617.49	2629.97
Annual rate	Subperiod (%)		3.5	6.9	5.0
	Accrued (%)		3.5	4.6	4.8
Foreign trade balance	PJ	-73.79	234.40	361.15	277.81

The foreign trade balances expressed in the table correspond to requirements that must be met above the domestic demand, i.e. exports less imports. As seen, exports would account for about 20% of domestic gas demand until the year 2010. After such date, the strong domestic demand increase, together with the expiry of the first export contracts, which are assumed as not to be renewed, reduces the importance of exports to 10% of domestic demand. Considering total requirements, domestic and external, demand would have a growth equivalent to 6.7% average annual rate until the year 2010.

Given that the domestic demand expansion would not be even in all consumption sectors, structural changes would occur in the sectoral structure as seen in Figure 31. In the base year, domestic gas demand was divided in thirds between power stations, the industry, and the residential, commercial, and public sectors, whereas compressed natural gas consumption (CNG) for transportation only accounted for 4% of the total demand.

Figure 31   Sectoral structure of natural gas domestic demand
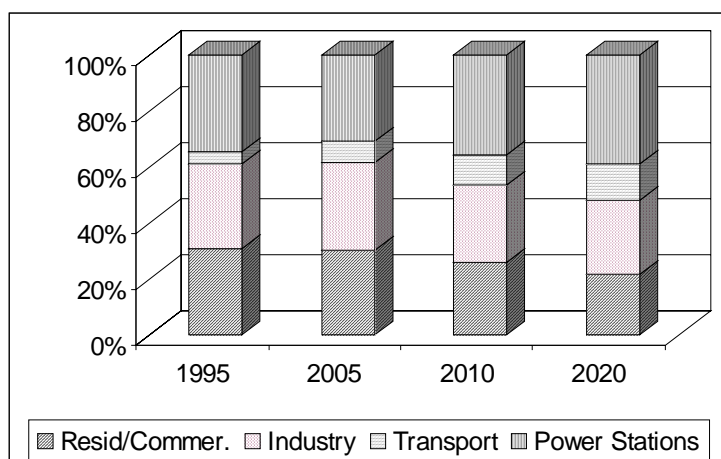
Electricity generators' strategy will substantially alter the structure towards the end of the period under analysis, as power stations shall account for almost 40% of total domestic gas demand. This, together with the high penetration assumed for CNG in transport, will reduce the share of residential and commercial consumption to fewer than 22%.

On the basis of expected gas requirements, the natural gas domestic gross production evolution was estimated considering the following:

143

1. transportation and distribution losses

2. self-consumption by the gas industry

3. the liquid hydrocarbons obtained from natural gas, and

4. gas vented in gas fields.

As explained when describing the baseline scenario, gas venting is expected to present the most substantial changes. New regulation would allow for drastically reduce the vented gas/production ratio (9% in 1995 to 2% in 2010), but also vented gas volumes are expected to decrease by 60% throughout the period even when production would be two and a half fold that recorded in the base year.

As result of such measures, the natural gas production annual growth rate would be almost 1 point below the growth rate expected in total gas requirements.

Although this study focuses on future energy use estimates and its purpose is to analyse the impacts of implementing mitigation measures and/or actions, it seems convenient to show the consequences of the expected gas production expansion on reserves. To that end, the amount of future gas discoveries in the country was estimated.

As this scenario assumes broad interest by gas producers in expanding their market, it was assumed that producers shall make an important investment effort to guarantee the sustainability of their strategy by intensively exploring the national territory, including both offshore and the sedimentary basins not explored yet.

It was assumed that by using new techniques for seismographic studies, together with more relevant exploration efforts, the average annual reserves discoveries recorded in late years could be increased some 40% in the future.

Thus, it was estimated that between 1997 and 2020 about 70,000 million m^3 of gas would be discovered each year. It should be noted that this incorporation pace of gas reserves is much more optimistic than the hypothesis considered by the Energy Secretariat in its Prospectiva 1997 study, where it assumes that annual gas discoveries will decrease in future from the present 50,000 million to stabilise around 40,000 million m^3.

Based on such hypotheses, the expected evolution of domestic natural gas reserves was calculated, and is illustrated in Figure 32, which shows also the trend expected in production.

As seen, after the year 2010, new reserves discoveries would not offset extractions due to the steady production increase and reserves would exhibit a clearly downward trend. In order to visualise the true impact of such opposing trend in reserves and gas production in the country, the reserves/production ratio was calculated as an indicator of the activity's timeframe under the operating conditions prevailing at the end of each year, illustrated in Figure 33.

As seen, in the first 10 years the reserves/production ratio shall fluctuate around 20 years. After that, the time frame shall systematically drop with the production increase, to reach values below 10 years after the year 2017.

The Argentine oil companies have stated on several occasions that keeping high reserves/production ratios implies maintaining idle capital with a high financial cost. However, the reserves/ production ratio is expected to be kept high in coming years as a way of obtaining permits for new exports.

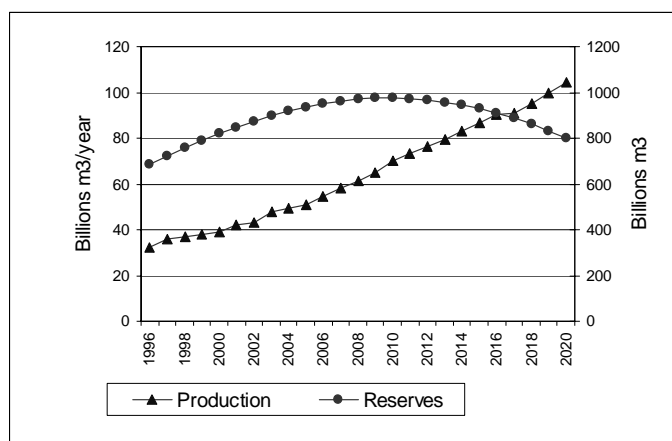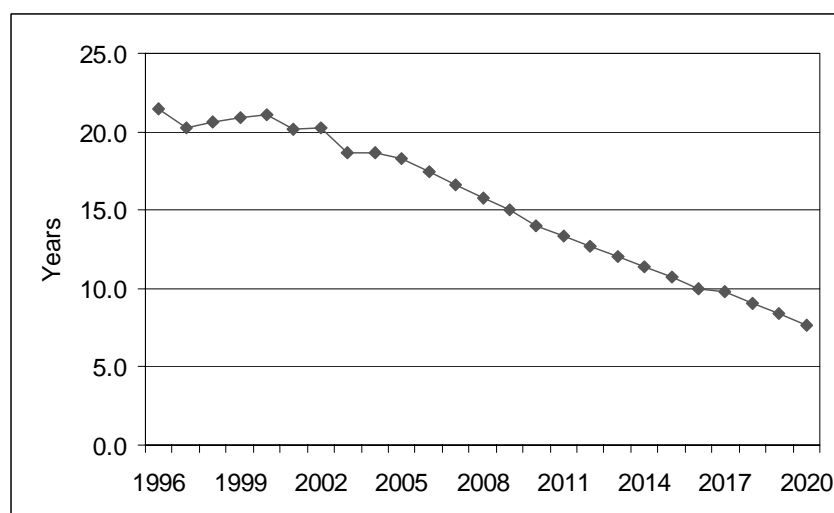*Figure 32   Natural gas production and reserves*

Figure 33   Natural gas reserves/production ratio

The activity's low time frame in the horizon year would endanger gas exports' sustainability beyond that date. The establishment of a regional gas market, including the reserves of Bolivia and eventually Peru could render more viable a strategy aimed at an intensive use of such source, relying on a moderate development by the Brazilian market.

The alternative to increase exploration efforts and expect larger reserves' discoveries than those assumed in this study seems rather unlikely. The evolution of reserves illustrated in Figure 33 implies incorporating throughout the period 1680 billions m³ to the 1996 reserves. In such case the total Argentine gas resource should amount to at least 2370 billions m³.

According to official data, and based on present knowing of gas basins, the total gas resource in the five presently productive basins reaches 1300 billions m³ including proven, probable, and possible reserves, i.e. 55% of the assumption made in the baseline scenario. However, recent private estimates[30] state that resources would exceed official values by

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[30]   Gaffney, Cline & Associates, Assessment of Natural Gas Export Applications in Argentina, November 1997

50%, amounting to 1900 billions m³. In spite of the improvement these new estimates imply, they still are 20% lower than the figure required for the operating condition assumed in the year 2020.

Therefore, it seems rather unlikely that the discoveries' pace assumed in the baseline scenario would be exceeded, as these incorporate Gaffney, Cline & Associates' expectation in the above mentioned study.

The evolution of reserves and production volumes in each productive basin, as well as capacity transportation expansion, should require a closer analysis, but it exceeds the scope of this project.

The possibility of consolidating in future an energy supply strategy based on the intensive use of gas shall depend on the efforts made to explore sedimentary basins within the national territory and on the success attained.

3.3   The oil industry

Table 36 illustrates the evolution expected in total petroleum products' consumption in the country, including both the consumption expected by end-use sectors and as input in transformation centres, regardless of whether it is devoted to energy or non-energy purposes. The table also includes each period's average annual growth rates, as well as those pertaining to the period accrued since the base year.

For the sake of presenting values, petroleum products were ranked in light products (LPG, kerosene, gasoline, and refinery gas); intermediate products (diesel oil); heavy products (fuel oil and petroleum coke); and non-energy products.

As seen, petroleum products consumption in the baseline scenario is expected to grow at a 2.9% average annual rate throughout the next 25 years, driven by increased consumption in agriculture, non-energy uses, and transportation, to a lower extent.

Table 36   Petroleum products consumption

|		1995	2005	2010	2020
Light products		353.0	338.1	354.0	387.9
Intermediate products		382.1	526.4	682.2	1158.1
Heavy products	PJ	89.5	67.8	83.1	110.3
Non-energy products		56.5	78.5	100.1	158.9
Total consumption		881.1	1018.8	1217.4	1815.1
Annual rate	Subperiod (%)		1.4	3.8	4.1
	Accrued (%)		1.4	2.2	2.9

However, the expansion pace of petroleum products' consumption in the country would be uneven throughout the whole period. It would grow gradually from a modest 1.4% in the next ten years to 4% between 2010 and 2020, influenced by the strong expansion of non-energy consumption and the use of diesel oil in agriculture.

Besides movements in the structure by sector of petroleum products' consumption, a change in the type of petroleum product demanded would occur throughout the period, as seen in Figure 34. In fact, while light products consumption would remain practically stable at present values, diesel oil demand would expand at 4.5% average annual rate in

the next 25 years, accounting for 64% of the country's total petroleum products consumption in year 2020.

In 1995, refineries' structure was adapted to obtain a higher proportion of light products (41% of total production) compared to intermediate (38%) and heavy (14%). The changes expected in the petroleum products demand structure would force a change in the refining structure, by incorporating catalytic hydrocracking plants in order to increase diesel oil production from fuel oil conversion. To fit the new demand structure, the capacity of catalytic-hydrocracking plants should expand from 2600 m³/day installed in the base year to 64000 m³/day in the year 2020.

Figure 34   Petroleum products consumption
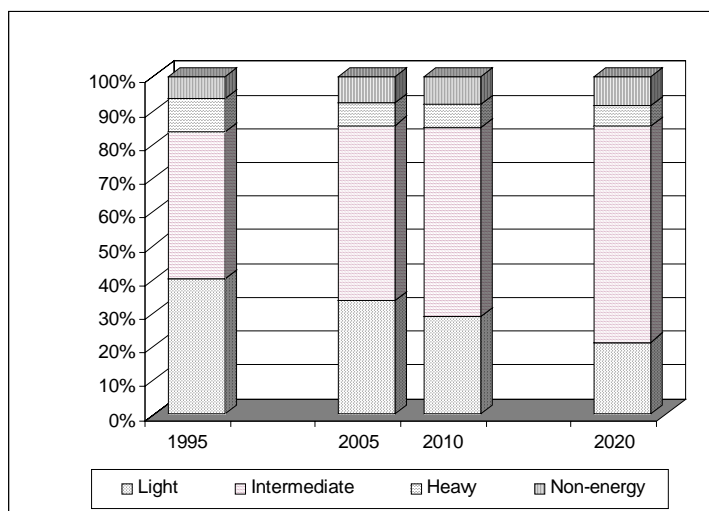
Additionally, to meet petroleum products' demand after the year 2010, the processing capacity of domestic refineries should be increased. Total additional capacity amounts to 48000 m³/day until the horizon year.

Based on such capacity expansion, local production for each type of petroleum product was estimated and plotted in Figure 35. The figure also shows the contribution of light products (LPG and gasoline) obtained at gas processing centres, with a growing share due to the expansion expected in gas production. In fact, while refineries accounted for 86% of domestic light products' production in the base year, they are expected to account for only 73% in the horizon year.

In spite of such refining structure changes, light and heavy petroleum products' exportable surpluses are expected to exist throughout the period. In the case of light petroleum products, exportable surpluses would grow systematically from 18% in the base year to 46% of the domestic production in 2020. Gasoline share in exportable surpluses would grow to 70% in the horizon year. Heavy petroleum products exportable surpluses would undergo a similar evolution, basically fuel oil, accounting for about 65% of domestic production after the year 2005.

The assumed downstream retrofitting would permit to self-supply diesel oil's demand until 2010. After that date, it would be necessary to complement domestic production with imports, i.e. 13% of the demand in the horizon year.

Forecasted crude oil input to domestic refineries were confronted to crude oil local production estimates derived from the strategy exhibited by producers, within the limits imposed by the country's oil reserves.

Figure 35   Petroleum products production
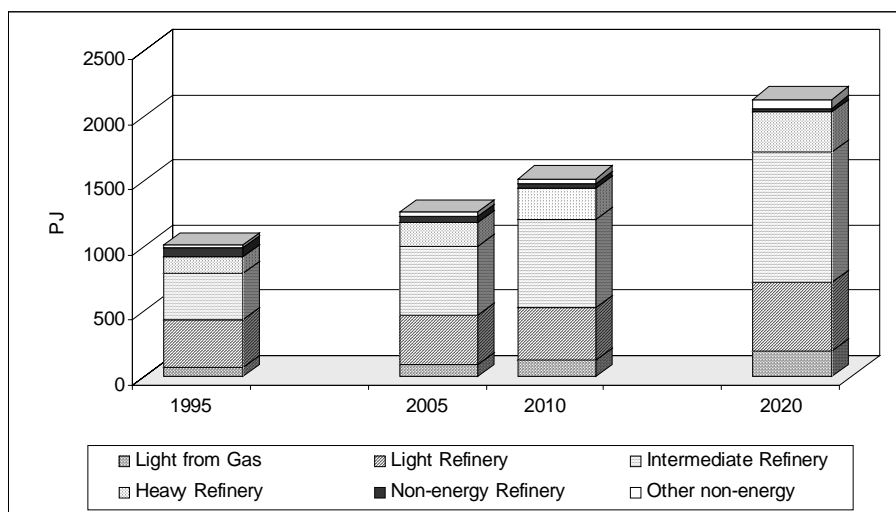
By the end of 1996, oil reserves amounted to 411 millions m³, while the volume in place was estimated at 2283 millions m³, i.e. the recovery factor was only 18%. Assuming that new oil exploitation techniques would augment the recovery factor to 30%, present reserves could increase some 274 millions m³, even if no new oil deposits were discovered.

As Argentine oil companies are expected to privilege their investments abroad as part of their strategy to become more internationally active, oil discoveries in the country was estimated in 40 million m3 a year, only 5% above the average recorded in the last 20 years. Such figures imply to add 961 million m³ in oil reserves, of which higher exploitation efficiency would contribute 28% whereas 690 millions m³ would come from new oil deposits.

Such oil availability in Argentina, together with the imposition to maintain an 8-year reserves/production ratio, would place caps on the possibilities to expand local crude oil production, in spite of the dynamics evidenced by private companies in the last five years. Based on such considerations, it was estimated that domestic crude oil production would plateau on 52 million m³ a year in 2002, a level that could be maintained until 2005. After such date, production would start declining to 35 millions m³ in 2020. Such crude oil production would be insufficient to meet refineries' requirements which would have to import about one third of their needs.

Figure 36 illustrates changes in crude oil sources and destinations in the country throughout the period under analysis as a consequence of operators' expected behaviour.

3.4   Primary energy consumption

Under the above described conditions, primary energy consumption would grow at 3.5% average annual rate along the next 25 years, with a faster pace after the year 2005 (4.3% annual) following the trends that had already been observed in final energy consumption.

148

Expectations for a more intensive use of natural gas in all sectors, including electricity generation, will deepen the historic oil and petroleum products substitution process, as seen in Figure 37.

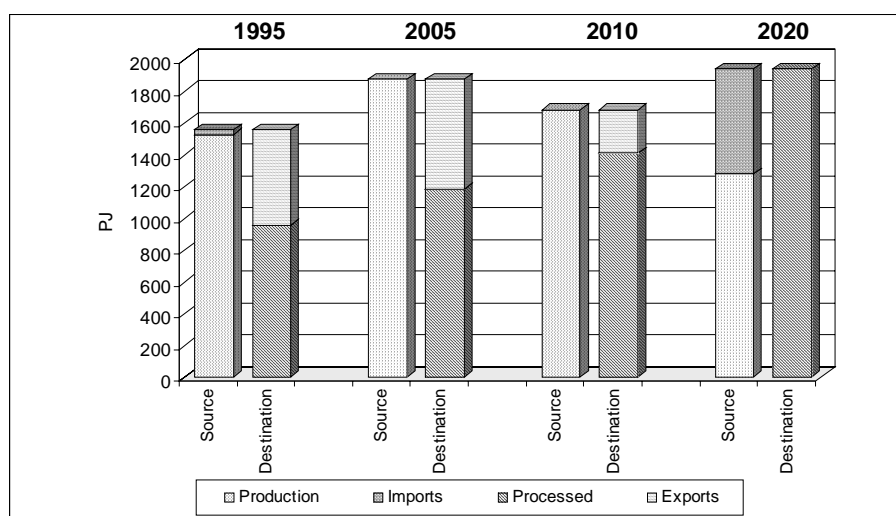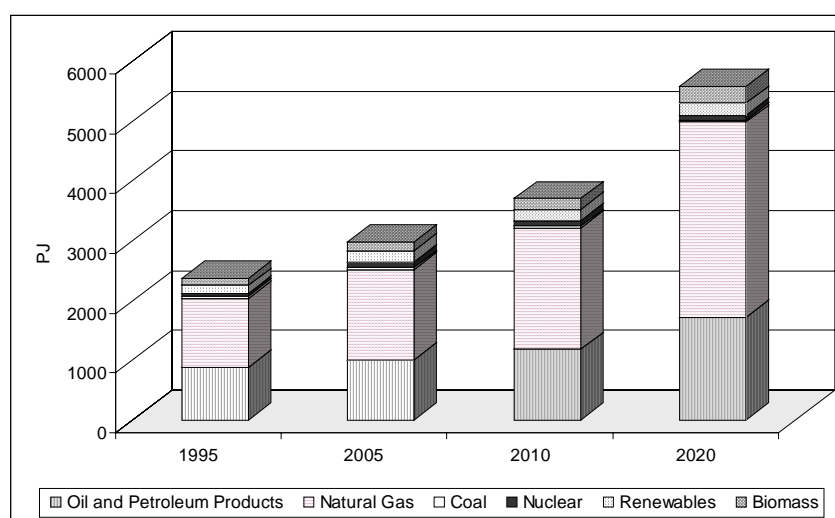*Figure 36   Crude oil sources and destinations*

Figure 37   Primary energy consumption

In fact, natural gas would increase its share in primary sources' consumption by almost 10 percentage points compared to the base year, i.e. close to 59% in 2020. Most of such increase would occur at the expense of oil and petroleum products substitution, which would supply fewer than 31% of primary energy consumption in the horizon year, versus the present 37%.

However, gas intensive use in power stations would also affect the share of renewable sources, nuclear fuel and coal, which, would lose jointly over 3 points. Hydroelectricity —which evidences a clear regression in electricity generation— was also included in renewable sources, as was wind energy, with a very low penetration in small isolated electricity systems.

Industry is the strongest biomass fuel consumer in Argentina through the use of wastes. The stability in such source's primary energy consumption share reflects that the expansion of agroindustry using biomass will be similar to that of the whole energy system.

Nuclear and renewable sources' regression would cause almost a 3 point increase in fossil fuels' total share, moving from the present 87% to 90% by the end of the period, although a higher proportion of "cleaner" fuels —in terms of GHG emission— would be used, e.g. natural gas.

Besides structural changes in primary energy consumption, a point to be highlighted is the increase in energy supply efficiency, i.e. the ratio between final energy consumption and primary energy consumption required to meet such needs.

Efficiency is expected to strongly increase in the next 10 years, moving from 76% to 81% in 2005. Such increase results from having assumed a substantial reduction in electricity transmission and distribution losses, the renewal of existing thermal generating capacity with highly efficient thermal power stations and substantial gas venting decrease in oil fields.

As improvements in the electricity industry are driven by operators' growing need to maintain their competitiveness in the market and as gas venting is under strict control, it seems reasonable to expect that strong efforts to reach higher efficiency will be made in the short and medium term.

In the long term, on the contrary, increasing efficiency would depend on technological progress, an area in which important advances have recently been made. Therefore, although improvements have been assumed, they are not expected to have the same impact. In any way, efficiency is expected to reach 83% in 2020.

Increasing efficiency, in both end-use and energy supply, would decrease primary energy intensity by 20% throughout the period under analysis, in terms of primary energy used per GDP unit. Although most of such decrease would be attained in the next ten years (15%), the trend would persist until 2020, as seen in Figure 38.

According to the changes expected in energy supply efficiency, it may be stated that activities related to energy supply shall contribute about 5% to the decrease in total energy intensity until the year 2005, while the remaining 10% would come from end-use sectors.

It should be acknowledged, however, that part of the energy intensity decrease expected in the next ten years would result from structural changes in the economy, with a trend towards a drop in energy-intensive activities' relative weight. There is no doubt, however, that growing competition on the countries' economic activities shall further higher energy efficiency, facilitated by state-of-the-art equipment availability.

The figure also illustrates the expected evolution in the per capita primary energy consumption, which evidences a clearly upward trend due to Argentina's low demographic growth rate.

4 GHG emissions in the baseline scenario

According to the results of the Inventory Report on Green House Gases (GHG) Emissions in Argentina, nitrous oxide (N_2O) emissions from the energy system are clearly negligible, accounting only for 0.2% of CO_2 emissions, even considering that their warming potential

150

is 320 fold that of CO_2 [31]. Given that such ranges fall within estimation errors, future N_2O emissions have not been estimated, and the analysis has been restricted to CO_2, CH_4, NO_x, and CO emissions for both scenarios.

Figure 38   Energy intensity and per capita consumption
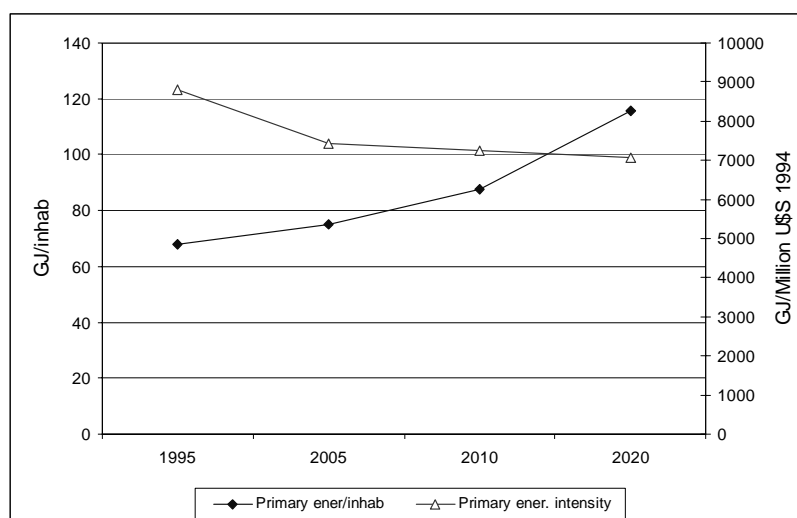
Such gases' emissions evolution, resulting from the baseline scenario hypotheses, is illustrated in Table 37 where inventory values have also been included in order to compare recent with long term expected evolution.

Table 37   GHG emissions in the baseline scenario

Gas type	Unit	Inventory		Mitigation study			
		1990	1994	1995	2005	2010	2020
CO_2	Gg	97402	109001	118190	143900	182620	281660
Annual rate	Subperiod (%)		2.85		2.0	4.9	4.4
	Accrued (%)				2.0	2.9	3.5
CH_4	Gg	371.8	474.9	35.0	61.1	108.4	203.1
Annual rate	Subperiod (%)		6.31		5.7	12.1	6.5
	Accrued (%)				5.7	7.8	7.3
NO_x	Gg	535.9	619.2	684.1	839.3	1083.8	1731.5
Annual rate	Subperiod (%)		3.68		2.1	5.2	4.8
	Accrued (%)				2.1	3.1	3.8
CO	Gg	1510.7	1735.7	1752.9	1624.5	1813.1	2052.0
Annual rate	Subperiod (%)		3.5		-0.8	2.2	1.2
	Accrued (%)				-0.8	0.2	0.6
CO_2 equivalent	Gg	132479	150611	151671	183842	234067	362052
Annual rate	Subperiod (%)		3.30		1.9	4.9	4.5
	Accrued (%)				1.9	2.9	3.5

[31] For the sake of comparing various GHG volumes, the following warming potential factors have been adopted:

CH_4: 24.5 (Source UCCEE)

N_2O: 320 (Source UCCEE)

NO_x : 40 (Source: IPCC)

CO: 3 (Source: IPCC)

As seen in the table, during the mitigation study estimates on methane emitted volumes were adjusted. The major difference between both figures lies in the way of accounting natural gas vented in oil fields. For the inventory, it was assumed that gas venting would not produce CO_2 and 100% was allocated to methane, with values close to 358 Gg in 1990 and 442 Gg in 1994.

However, recent studies have shown that a significant part of vented volumes correspond to a mix of natural gas and dissolved CO_2 (40% average) which would be released into the atmosphere. Additionally, the greater proportion of natural gas vented in oil fields is burnt in flare, thus emitting additional amounts of carbon dioxide but substantially reducing methane emissions.

When emissions were determined in the mitigation study, such fact was borne in mind, which explains methane emissions' substantial reduction between 1994 and 1995 that appears in Table 37 above. Simultaneously, CO_2 emissions were adjusted (increased), this is not clearly depicted in the table because of their low incidence compared to the impact of energy consumption's variations between 1994 and 1995.

As seen in the table, the major energy system's emissions correspond to carbon dioxide, although methane emissions' growth will be much faster in future. In order to analyse the relative importance of these two gases, the expected evolution of CO_2 volume equivalent to the four gases' joint emissions, considering their respective global warming potentials, was also included in the table.

In spite of the different growth pace, direct CO_2 emissions would account for about 78% of the total throughout the period, whereas methane would slightly exceed 1% in the horizon year. Such result differs from the one appearing in the GHG inventory for Argentina, where CO_2 accounted for 72% of the total in 1994 and methane for almost 8%. The changes introduced in allocating the emissions from gas vented notably decreased the relative importance of methane in total emissions from the energy system.

The following paragraphs analyse the expected evolution of gas emissions, emphasising CO_2 emissions because of its relative importance.

4.1 CO_2 Emissions

### 4.1.1 The evolution of total CO_2 emissions

Total CO_2 emissions is expected to grow at a lower pace in the next 10 years than in the first five years of this decade, due to both the slower economic growth rate assumed and the higher energy efficiency, as mentioned in this Chapter's previous sections. However, the expected 2.0% annual average growth would broadly exceed that recorded in the country in the last 25 years, 1.5% per annum as seen in Chapter II, Section 4. In any way, one should bear in mind that such historic records include long recessive cycles of the Argentine economy, whereas projections made forecast a steady economic growth, which in average would reach 4% annually throughout the next ten years.

After the year 2005, the emission increase would gain pace, driven by consumption growth and the energy supply strategy, as illustrated in Figure 39.

The greater contribution to moderate carbon dioxide emission growth in the next ten years would lie in energy supply-related activities, especially power stations and the gas industry. In the former case, thanks to both higher generation from hydroelectric power plants and the reduced heat rate in fossil-fuelled power stations, while the gas industry will contribute mainly by reducing gas vented in oil fields.

152

It should be noted that in the case of the gas industry lower emissions would result from an explicit policy by the energy authorities instrumented through specific regulations about natural gas venting. From oil producers' standpoint, complying with the regulation involves related costs, which in certain fields could affect crude oil extraction pace.

Figure 39   Total CO$_2$ emissions
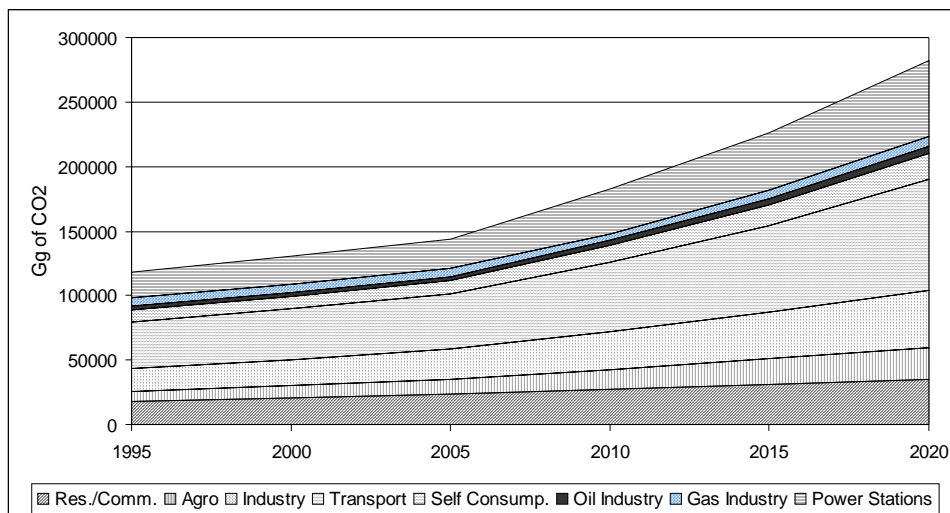
Because of its impact on CO$_2$ and CH$_4$ emissions and in relation to international agreements for climate change mitigation, such policy could be included as a mitigation action already implemented in the country at its own cost. However, its effects have been incorporated to the baseline scenario, in the understanding that this study aims at analysing the mitigation potential of new actions that could be added to those already implemented.

End-use sectors, except for transport, would maintain faster growth rates, producing jointly 70% of total emissions compared to 67% in 1995. The expected changes in the transport sector would permit to revert the strong upward trend recently evidenced by emissions from this sector, foreseeing an average growth of about 1.6% per annum, well below the growth expected for other end-use sectors. Thus, the share of transport in total CO$_2$ emissions is expected to drop almost 3 points with respect to 1995.

As of the year 2005, increased generation in fossil-fuelled power stations would induce an average CO$_2$ emissions growth from power stations of 6.5% per annum until the horizon year, in spite of having assumed a strong improvement in their thermal efficiency. Thus, in the horizon year power plants would account for almost 21% of total CO$_2$ emissions in the country and 63% of total emissions from energy supply activities.

In a strongly expansive context of total CO$_2$ emissions (average rate: 4.6% annually) only the residential and commercial and public sectors exhibit a lower growth than the whole energy system, dropping their share by 4 points in the 2005-2020 period. Contrarily, the increase in mechanisation and the expansion of agriculture and cattle-raising activities would increase such sector's relevance in total CO$_2$ emissions, moving from 6.5% to about 9% in the horizon year. A similar behaviour would be evidenced by industrial emissions, whose share would grow slightly above 1 point throughout the period under analysis.

Evolution of CO₂ specific emissions

Following the same criteria used in the historic analysis of CO_2 emissions, indicators were calculated to measure the "environmental efficiency" of the energy system, as a whole and for end-use sectors and energy supply as well.

At the energy system level, total CO_2 emission per unit of non-biogenic gross energy supply was calculated, whose results are illustrated in Figure 40.

As for consumption, the ratio between total CO_2 emissions from end-use sectors and the corresponding non-biogenic final energy consumption appears in the same figure under the label "Final Consumption". Even if excluding emissions from biomass fuels is a current practice in this type of analysis, it should be remarked that biomass consumption in Argentina only accounts for about 6% of final consumption

Emissions from energy supply were related to all the energy supplied and not used by the end-use sectors, assuming that CO_2 emissions from energy supply originates in both energy self-consumption and handling total energy losses (transmission, distribution, transformation, and unused). Such indicator's evolution is illustrated in Figure 40 under the label "Supply".

As seen in the figure, total specific emissions shall remain relatively stable throughout the period, as the horizon year value will surpass the one recorded in the base year by only 1%, although in 2005 such emissions would reach a minimum equivalent to 97% of present values. Long-term stability of total specific emissions implies interrupting the historic trend, which meant a 25% drop during the last 25 years.

Figure 40   CO₂ specific emissions
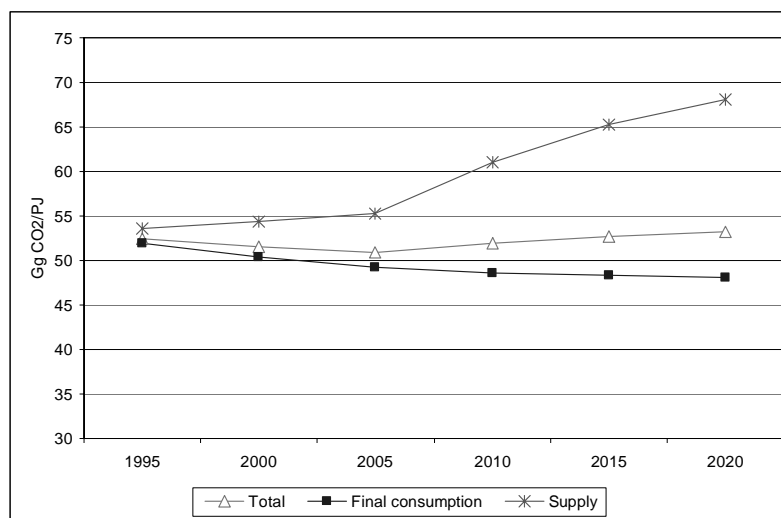
Comparing the three curves it becomes evident that energy supply shall be mainly responsible for this behaviour, as their specific emissions would grow 23% after the year 2005. On the contrary, specific emissions from end-use sectors would continue along the downward historic trend although somewhat attenuated. In fact, such indicator is expected to decrease by 8% in the next 25 years, compared to 12% recorded in the last 25 years.

In order to help understand such results, indicators were calculated for the energy supply activities that are highly responsible for CO_2 emissions: power stations, energy industries'

154

self-consumption, and fugitive emissions in the gas industry, whose expected evolution is illustrated in Figure 41.

Figure 41   CO₂ specific emissions from energy supply
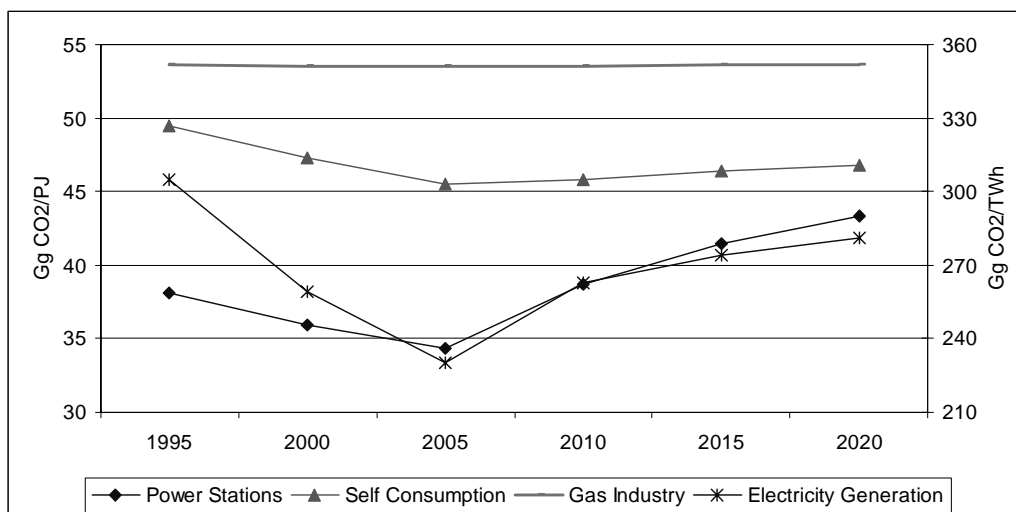
For power stations, two indicators were calculated. The first one identified in the figure under the label "Power Stations" accounts for CO_2 emission per unit of energy input to power stations (Gg of CO_2/PJ). The second indicator links power stations' emissions with their electricity production (Gg of CO_2/TWh) and appears under the label "Electricity Generation".

The gas industry indicator reflects both fugitive emissions from gas venting and emissions from transportation and distribution losses, while emissions from energy consumption by gas supply were considered with the remaining energy industries' self-consumption.

The trend of the indicators for power stations clearly changes towards 2005. Before such date, specific emissions from power stations would continue along their downward historic trend to then exhibit a steady growth until the horizon year.

By definition, variations in specific emissions from power stations reflect changes in the type of energy sources used for electricity generation. As seen in Section 3, emission-free sources (hydraulic and nuclear fuel) is expected to increase their share by 10% in the next 10 years, while the switching from petroleum products and coal to natural gas will continue. The combined effect of both facts would be a 10% reduction in emissions per energy unit used in power stations.

When analysing power stations' environmental efficiency in terms of their activity level (TWh generated), it can be seen that the reduction would amount to 25% until 2005. The additional 15% savings, compared to specific emissions per unit of energy input, reflects the expected improvement in thermal efficiency of fossil-fuelled power stations. In fact, power stations average heat rate would decrease from the present 1900 Kcal/kWh to 1600 Kcal/kWh in 2005, reaching an average efficiency of 54%. It should be pointed out that these values are impacted by the 80% performance assumed for hydropower stations.

After 2005, the amount of natural gas burnt by power stations is expected to grow strongly, replacing, besides other fossil fuels, zero-emission sources (hydro and nuclear) which would decrease their share by 50% throughout this period. The natural

155

consequence would be a 26% increase in the volumes emitted per unit of energy input to power stations, as seen in Figure 41. Thus, specific emission in the horizon year would be almost 14% higher than present figures.

The increase in emissions per TWh generated in the same period would be slightly lower (22% over the 2005 values) thanks to the persistent improvement in thermal efficiency. In fact, this efficiency improvement would allow to lower 1995-CO_2 emission per kWh generated by 8% in the horizon year, in spite of hydro and nuclear generation's loss of share in the next 25 years.

The growth pace in emissions from power stations will be substantially lower than what can be expected when implementing an expansion strategy based on fossil-fuelled generation, because of the adoption of state-of-the-art technologies, promoted by competition between generators. Such type of decisions, which in other systems could be considered mitigation actions, will naturally occur as part of electricity generators' business strategy. In any way, such decisions still contribute to climate change mitigation.

The CO_2 emitted per unit of energy consumed by the energy industries (self-consumption) would also reverse its downward trend around the year 2005. The subsequent slight growth (3% in 15 years) would be linked to the natural gas industry's substantial expansion to meet a strongly growing demand.

The specific fugitive emissions from the gas industry simply reflect natural gas emission factor, as this is the only energy source involved in the process.

The switching from petroleum products to CNG in end-use sectors would allow for reducing their CO_2 emissions. As a result of such substitution, specific emission from transportation would persistently decrease throughout the period, resulting in a 7% drop in the horizon year, as seen in Figure 42.

Figure 42 CO_2 specific emission from end-use sectors
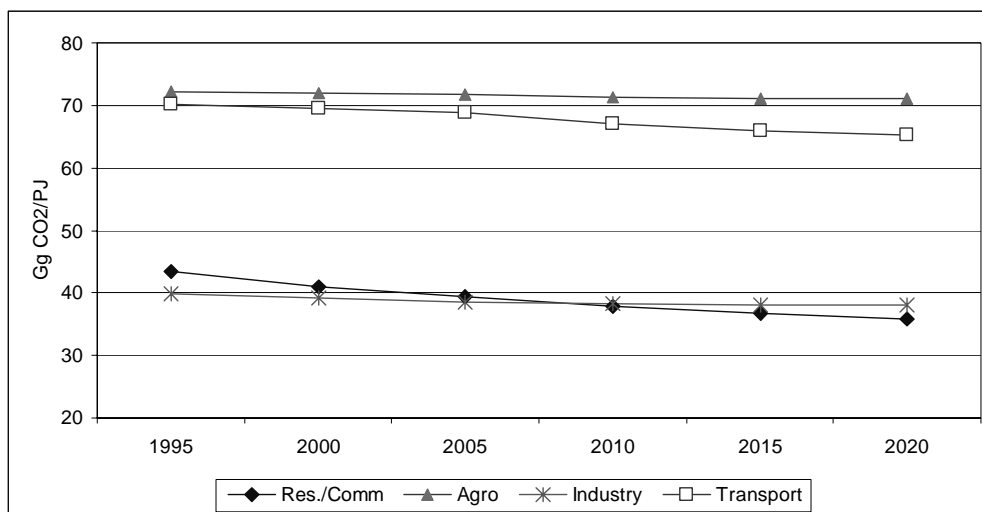
In the case of residential, commercial, and public sectors, the substitution process for cleaner sources in terms of carbon dioxide emissions would retain the historic downward trend of their specific emissions in the future. Throughout the period, an 18% reduction compared to present records is expected.

156

On the contrary, in the industry and agricultural and cattle-raising sectors, specific emissions would remain practically constant until the horizon year, reflecting the end of petroleum-products substitution process that took place in the past. It should be pointed out that specific emissions from the industry was computed as the ratio between emissions and total non-biogenic energy consumption, whatever the purpose, as energy or production input.

Energy and CO$_2$-emission pathways

The energy pathway graphically represents the trajectory of energy intensity (energy supplied per GDP unit) as a function of the per capita GDP variations. A similar curve can be plotted for CO$_2$ emissions, the emission pathway, representing the evolution of emissions per GDP unit according to changes in the per capita product.

Figure 43 illustrates energy and CO$_2$ emission pathways for Argentina in the 1995/2020 period, corresponding to the baseline scenario hypotheses, taking as 100 index the pertaining intensities in 1995.

*Figure 43   Energy and CO$_2$ emission pathways*
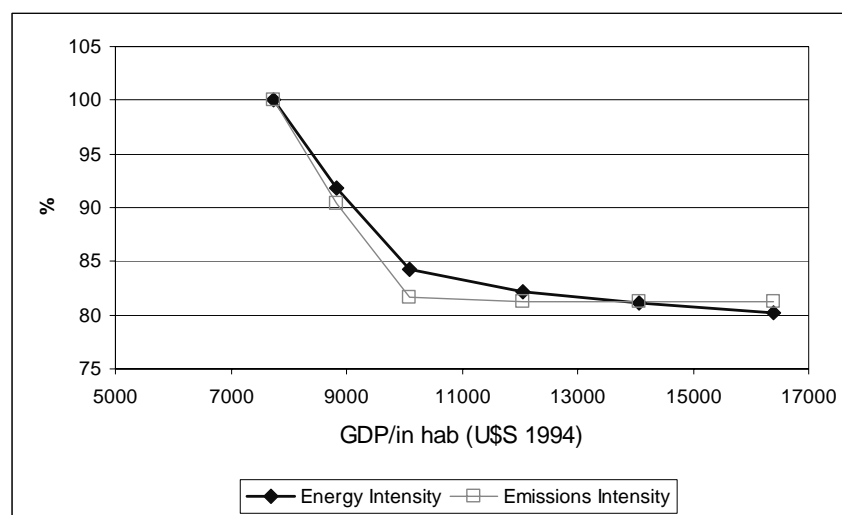
As seen in the figure, energy intensity in Argentina is expected to decrease 16% in the next 10 years due to higher energy efficiency in end-use and supply, although the structural changes in the economy foreseen in the scenario towards less energy-intensive activities will also contribute to attain such results.

During the same period, emissions intensity from the Argentine economy shall drop further (slightly above 18%) which, as seen, results from intensifying the use of less CO$_2$-emitting energy sources. It should be highlighted that such trends would occur in a clearly expansive context of the economic activity permitting to increase by 30% the present per capita product values.

After the year 2005, the 5 % reduction in energy intensity will reflect the expectation for energy efficiency improvements due to technological innovation, as it was assumed that the structural reforming of the economy in Argentina would have ended before such date. However, the higher efficiency would not be reflected in the carbon dioxide emission intensity mainly due to the strategy adopted for electricity supply, whose increased emissions offset savings from the efficiency gain.

This fact is clearly reflected when analysing the specific emissions' pathway, illustrated in Figure 44. As seen, the specific emission growth in the last 15 years of the period would more than offset the reductions expected in coming years. However, specific emissions would increase only 1% compared to present values.

Figure 44 CO_2 specific emission pathway
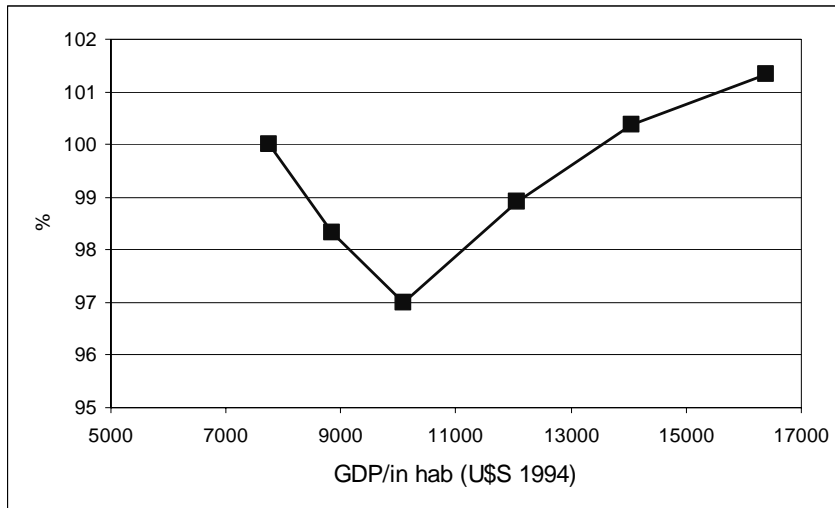
4.2   Methane emissions

Methane emissions from the energy system originate in natural gas leaks during such fuel's production, transportation, and consumption, and from light liquid fuels' volatilisation.

In the case of the natural gas industry, and as previously commented, the actual methane emission are much lower than those initially assessed in the first versions of the GHG inventory for Argentina. Consequently, presently energy supply contribute less than 1% to the energy system's total CH_4 emissions.

In future, a decrease is expected in the share of supply in methane total emissions, until accounting for only 0.2% in the year 2020. The key element in such reduction shall be the effective control of gas vented in fields, as assumed in the baseline scenario.

New regulations on gas venting in the country are so restrictive that they would reduce total methane emission from gas venting in the year 2020 below 1995 figures, in spite of natural gas production expansion (5% average annual rate during the whole period). Given the methane's high global warming potential, such regulations will no doubt significantly contribute to climate change mitigation.

In spite of gas production and consumption's expansive context, the gas industry as a whole (considering losses and venting) would only increase by 12% its total methane emissions throughout the period.

The behaviour expected from the gas industry places end-use sectors as the main responsible in the future for methane emissions from the energy system. In fact, future CH_4 emissions growth shall be propelled by the transport sector, whose share would persistently grow to reach slightly over 97% in the horizon year, versus the present 95%.

158

In order to compare such emissions with the evolution expected in the transport sector, the methane emission per unit of energy used for transportation was calculated whose evolution is illustrated in Figure 45.

Figure 45   CH₄ specific emission from transportation
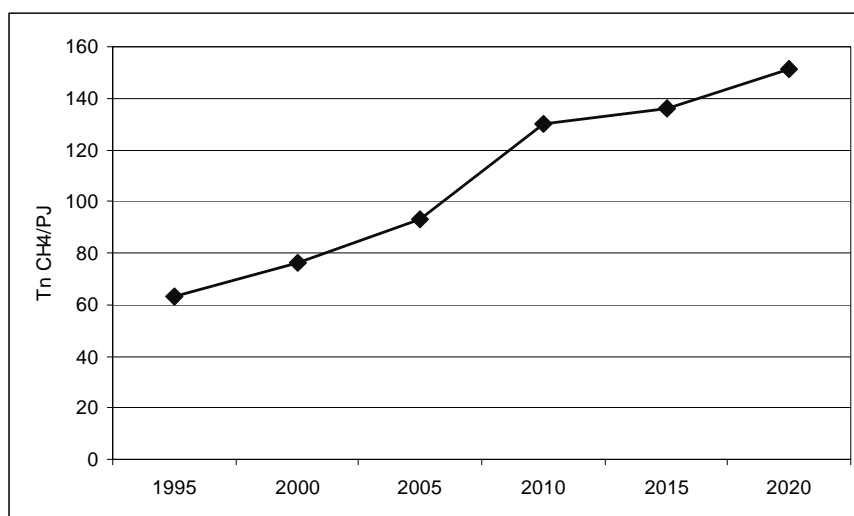
As seen, specific emission would grow by 140% throughout the period compared to base year values, with a faster pace after the year 2005. Such growth will be driven by the higher CNG use. Somehow, such behaviour would be the counterpart of the benefits contributed by CNG in terms of CO_2 emissions. In any way, and in spite of methane's higher global warming potential, the balance in CNG use would be positive as regards its contribution to climate change mitigation.

4.3   NOₓ emissions

The evolution in NO_x emissions would be mainly defined by three sectors: transport, agriculture and cattle raising, and electricity generation, as illustrated in Figure 46. In the base year, its emissions already accounted for slightly over 83% of total NO_x emissions from the energy system, its importance however, would increase throughout the period to reach 87% in the horizon year.

The trends of such emissions are, however, different. In fact, the agriculture and cattle raising sector would move from the present 23% share to 29% of total emissions in the year 2020, due to the important increase in diesel oil consumption. On the contrary, transport —which contributes nowadays 50% of total emissions— would lose almost 5 points by the end of the period thanks to the changes expected in the type of energy source used for transportation.

The increase in fossil-fuelled electricity generation, even burning natural gas, would cause NO_x emissions from power stations to grow at a pace faster than that of the energy system as a whole, increasing its share in the total by almost 2 points, from 10% to 12% throughout the period.

It should be pointed out that the emission factors used in the LEAP environmental database for the study are those employed to calculate the GHG inventory for Argentina, in order to retain the possibility to compare results. Therefore, NO_x emission factors used for the power stations correspond to those proposed by the IPCC.

Figure 46   NO$_x$ emission
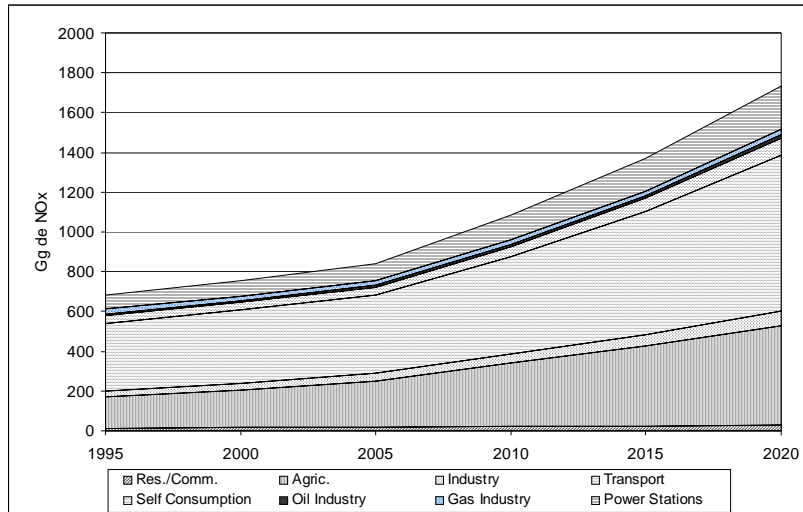
However, the inventory report makes clear in one of the annexes that the measurements made by the Electricity Regulatory Body (ENRE) at thermal power stations chimneys indicate that real emissions produced by gas turbines burning natural gas are lower than those resulting from IPCC emission factors. It is the opinion of the ENRE that the difference would become more noticeable in future, when state-of-the-art gas turbines with NO$_x$ emissions between 40 and 50 ppm are massively incorporated.

The Energy Secretariat, in its Prospectiva 1997 Study, estimated that real NO$_x$ emissions in thermal power stations in 1994 would have been 30% lower than GHG inventory estimates, considering the changes in the thermal installed capacity and the lower NO$_x$ emission factors resulting from the ENRE's measurement campaigns.

Differences would broaden in future with a higher share of power stations fitted with low NO$_x$ emission burners, as assumes the Prospectiva 1997 Study foreseeing a decrease in total NO$_x$ emissions from power stations in spite of the increase in share by thermal generation.

Although NO$_x$ emissions from the energy system are not too relevant in the GHG as a whole, the values appearing in the figure for power stations should be considered as preliminary and should be subjected to a deeper analysis.

4.4   CO Emissions

Practically 99% of CO emissions result from end-use sectors, although the growth of emissions in power stations shall dynamise the increase in the energy supply share, which in any way shall only represent less than 2% of the total in the horizon year.

Most CO emissions from end-use sectors (99%) originate in transport and agriculture and cattle raising, although both sectors evidence an opposite trend. The strong growth of emissions from the agriculture and cattle raising sector will increase its share to 10% of total CO emissions in the horizon year at the expense of the transport sector's share, whose contribution would drop 6 points.

Mitigation scenario

1   Characteristics of the mitigation scenario

For the sake of this study, the mitigation and baseline scenarios for Argentina only differ inasmuch as the former involves implementing options and actions to mitigate GHG emissions within the territory of Argentina. Energy industries' organisation and operators' interest would remain unchanged, although their business strategies should adapt to the new context defined by official climate change mitigation policies.

In any way, a deep analysis on the mechanisms that should be used to alter private agents' decentralised decisions towards lower GHG emissions is beyond the scope of the present study. Implementation issues in the power sector are discussed in the separate report "Implications of Electric Power Sector Restructuring on Climate Change Mitigation". Therefore the results presented herein should be interpreted as Argentina's contribution to climate change mitigation in case mitigation policies were successful.

In simulating the energy system's operation, whose results appear in Sections 3 to 5 below, some general hypotheses about key aspects were assumed to define agents' expected behaviour vis-à-vis official mitigation policies. Such aspects refer to:

1. Sectors and/or activities on which mitigation efforts would focus,
2. The international context for mitigation policies adopted in Argentina,
3. Domestic energy products' pricing policy, and
4. The impact on energy foreign trade.

The following paragraphs summarise the hypotheses adopted with respect to each of such topics.

1.1   Sectors under analysis

As this scenario aims at making advantage of the best opportunities to reduce energy end-use and, consequently, GHG emission, it has been considered that efforts should aim at transportation and industry.

In the case of transportation, the baseline scenario had already assumed an improvement in vehicles' energy performance, following the international automobile industry and local branches' trend. As discussed in detail in the next section when presenting the mitigation options considered, the mitigation scenario involves a substantial change in transport policies that affects the share of transport means and modes besides increasing the penetration of vehicles capable of reducing petroleum products consumption.

As regards passenger transportation, for instance, attempts have been made to measure the impact of prioritising the implementation of new measures for traffic organisation, substitution between modes, sources and further technical enhancements in vehicles.

In such sense, traffic organisation measures involve the road system's extension and improvement, expansion of elevated railways and subways, limiting private cars' circulation in certain urban areas, among others.

Substitution between modes focuses on increasing public transport to replace automobiles and the switching from trucks to railways for freight transportation. Additionally, promoting less emitting energy sources (CNG) and decreasing the age of the car fleet are assumptions made to improve mean specific consumption.

The Workshop "Technological Innovation and the use of energy", carried out in Buenos Aires on June 1997 as part of the present project, concluded it would be convenient to focus rational use of energy policies in industrial activities less subjected to international competition. Those manufacturing activities having more exposure to international competition shall be forced even in the baseline scenario to increase their energy efficiency.

On such basis, the mitigation options under analysis focused on major energy consuming industries, of which substantial medium and long term growth is expected and where a significant portion of the installed capacity is obsolete.

Actions focus on heat and mechanic uses, while the role of cogeneration is additionally assessed. As for heat and mechanic uses process modifications are assumed, as well as partial equipment replacement and general energy conservation measures.

As regards supply-related activities, special attention was paid to electricity generation because of its highest fuel consumption in the energy sector. In this case, mitigation options cannot be based on energy efficiency improvement, considering fossil-fuelled plants' high future performance. Therefore the search aimed at GHG emission-free technologies, as discussed in Section 2 below.

As for the remaining energy industries, baseline scenario assumptions do not allow for energy efficiency increases. Particularly stringent regulations on natural gas venting in gas fields implemented one of the few mitigation options for such activities.

1.2   The international context

As mentioned when defining the present study's energy-environmental international context (Chapter IV, Section 4), it was assumed that international concern for atmospheric GHG concentration and the decision to cap emissions shall gradually consolidate in coming years, regardless of whether developing countries implement mitigation actions within their territories or whether they do not.

Consequently, and both from the standpoint of pressures in the international commodities markets and in cleaner technologies' availability, no substantial differences were assumed between both scenarios.

In the case of crude oil international market, the price growth shall result from the success in reducing fossil fuels burning in major consumer countries and the type of instruments used to promote such behaviours.

If the consumption decrease reached significant sizes, pressure would result in a price drop. However, a strong drop in crude oil and petroleum products' price could offset efforts to reduce consumption and promote the use of new technologies.

In such situation, the introduction of market-oriented policy instruments, e.g. "carbon-tax", would generate a counter force on prices, with results dependent on the size of

162

both phenomena. Anyway, petroleum products' price is expected to maintain or increase its value for end users.

However, the situation would be totally different for oil producers. Firstly, certain producers will try and maintain the quantities produced, even at the cost of price. Over-supply, plus the relative price raise of petroleum products compared to substitute energy products, could exert pressure on crude oil's international price. The effect of such market-oriented type of measures would strongly impact oil producers by decreasing the oil rent.

Although it is true that costs still allow for such manoeuvres, less dynamism should be expected in the oil industry, especially in exploration investments in riskier basins.

As a result of such considerations it has been assumed that crude oil international price would be slightly lower than that calculated for the baseline scenario, even if the drop remains hidden for petroleum-products' end users.

1.3   Domestic prices

The major hypothesis in this scenario is that State intervention in energy markets shall be minor to ensure mitigation policies' success, i.e. domestic prices shall remain in line with international values. Therefore, all the comments made in the previous paragraph are applicable to the domestic situation.

Particularly, exploration efforts within the national territory could be affected even more than in the baseline scenario. Beyond the harm such situation could cause to companies in the sector, crude oil supply and petroleum products' domestic needs would not be affected thanks to the decrease in domestic demand achieved through mitigation actions.

From the standpoint of economic development, a decrease in the oil billing would neither affect the public sector funding nor have a major impact on Argentina's total exports.

Although mitigation actions could result in a decrease of natural gas' domestic demand, as a cleaner fuel than petroleum products it could undergo a higher relative appreciation. However, such differences should not be substantial for substitution processes not to be affected.

As for the electricity market, thermal power plants shall still define prices, in spite of the incorporation of power plants with GHG emissions-free technologies. Therefore the price of electricity in the wholesale market would still be tied to gas for power plants' price evolution. The success of an electricity generation diversification policy shall specifically rely on finding the right mechanisms to balance generators' economic equation to face higher investment costs.

1.4   The foreign trade of energy

As a simplifying hypothesis, it was assumed that projects related to natural gas and electricity exports would not be highly impacted by mitigation policies.

2 Mitigation options in consumption sectors

As already mentioned in Section 1 above, the mitigation options under analysis focus on industry and transportation as well as on the energy supply activities. The hypotheses and actions assumed for each case and their rationale are described here in below.

2.1   Transport sector

Mitigation options aim at deepening the various changes expected in the sector and include additional actions. Both aspects involve explicit interventions to orient energy consumption towards GHG emissions decrease. Items under consideration are still the following:

- Traffic organisation measures
- Substitution between modes
- Technical improvements and energy sources penetration

For each of them, explanations are provided on the new options that would permit to improve the sector's "productive efficiency" with beneficial consequences on expected emissions.

2.1.1 Traffic organisation measures

Modifications have been assumed related to urban, suburban and interurban transportation. In the first case the following are added to those presented in the baseline scenario:

- Construction of highways or belt roads in cities with over two hundred thousand inhabitants, improving the transit flow, increasing the mean circulation speed and decreasing waiting time in all intermediate and large cities of the country.
- Construction of subways or elevated trains in Mendoza, Tucumán, the Greater Buenos Aires, Bahía Blanca and Mar del Plata between the year 2010 and 2020, to replace private cars and buses. The following passenger transport system extensions have been considered:
    - Two twelve-kilometre subway-lines in Mendoza, Bahía Blanca and Mar del Plata
    - Two twenty-kilometre subway-lines in Tucumán and the Greater Buenos Aires
- Maintaining regulations on private cars and buses' circulation in central urban areas, aiming at decreasing or eliminating transit in such areas, preventing traffic jams and unnecessary energy consumption.
- Maintaining regulations that ban heavy-duty trucks in urban areas, to prevent them from driving in densely populated areas.

As regards suburban areas, the following is expected:

- Construction of new suburban highways in Greater Mendoza, Greater Tucumán, Greater Bahía Blanca and Greater Mar del Plata

164

- The hypothesis on satellite cities is maintained, as sleeping areas for large cities. That means: administrative activities in the cities and industrial activities in the periphery. Enhancement of services in the periphery to prevent the traffic of people towards densely populated areas.

As for interurban transportation, the following has been considered:

- The Salta-Tucumán, Formosa-Santa Fé, Corrientes-Paraná, Bahía Blanca-Neuquén-Bariloche, Bahía Blanca-Rio Gallegos, Mendoza-Neuquén highways are included.

2.1.2 Substitution between modes

In this case the assumptions also refer to the urban, suburban and interurban area. The hypotheses assumed in the baseline scenario for the urban area are expanded, increasing mode substitution and penetration percentages.

The switching from private cars to urban buses increases between 10-15% as compared to the baseline scenario. It has been also assumed that subways will transport an additional 3% of total demand (passengers-km) in 2010 and an additional 5% in 2020.

Cars' utilisation factor increases from 1.56 passengers/vehicle in the base year to 2.0 passengers/vehicle in 2010 and 2.2 in 2020. Buses and subways are expected to maintain constant their utilisation factors.

As for suburban and interurban areas, enhancement of baseline scenario's trend has also been assumed, including: greater penetration of buses (additional 10% with respect to the baseline scenario) and railways replacing buses (additional 10%):

Regarding interurban freight transportation, railways penetration is expected, an additional 10% to that expected in the baseline scenario after 2010, replacing road transportation (truck). On the other hand, the role of the railway-truck combination expands, increasing by 20% the figure assumed in the baseline scenario, after 2010.

Finally a more significant role should be attached to river transportation to replace trucks. According to baseline scenario projections the role of barges in river transportation is expected to increase by 20% after 2010.

The above-mentioned actions would allow for an improvement in energy efficiency both in passenger and freight transportation, involving additional local benefits.

2.1.3 Technical improvements and source penetration

Various hypotheses are presented regarding cars, buses, light duty trucks (below two tons of freight capacity) and railways. In the first case the following has been assumed:

- Better performance
- Switching from gasoline to diesel oil and CNG
- Launching of the first electric and hydrogen-fuelled vehicles between 2015-2020. Expected penetration: 6% of the market in 2020.

Private cars and taxis

Automobiles' performance improvements are expected to reach the following values:

<p style="text-align:center">Table 38   Expected performance improvements for automobiles</p>

Fuels	1995	2005	2010	2020
Gasoline lts/100km	10.5	10.0	8.2	5.5
DO lts/100km	7.8	7.4	6.5	5.0
CNG m^3/100km	11.42	10.88	8.9	6.0

The technical improvement with respect to the baseline scenario is assumed to result from higher penetration of more efficient cars promoted through different actions such as: promotion oriented credits, rate rebates, regulations for the manufacturing of more efficient cars, differential prices, etc.

The penetration of diesel oil, CNG, electricity and hydrogen increases:

<p style="text-align:center">Table 39   Penetration of diesel oil, CNG, electricity and hydrogen increases</p>

Cars	1995	2005	2010	2020
Gasoline	84.4%	70.3%	59.5%	39.8%
Diesel oil	3.5%	11.4%	17.2%	23.7%
CNG	12.1%	18.3%	22.3%	33.3%
Electricity			0.1%	0.4%
Hydrogen			0.9%	2.8%

Electric cars account for 2% of the fleet in 2020. Hydrogen-driven cars account for 3% of the fleet in 2020.

Urban and long-distance buses

As for buses, switching diesel oil to CNG is expected according to the following percentages:

<p style="text-align:center">Table 40   Growth of CNG bus fleet</p>

Buses	1995	2005	2010	2020
Diesel oil	100%	86.6%	86.0%	39.7%
CNG		13.4%	13.5%	55.2%
Hydrogen			0.5%	5.1%

Specific energy consumption shall improve reaching the following values:

<p style="text-align:center">Table 41   Performance of bus fleets</p>

Buses	1995	2005	2010	2020
Diesel oil lt/100km	29	27.6	24.1	18.5
CNG m^3/100km		40.5	35.7	27.8

Changes expected in the bus fleet would materialise through regulatory mechanisms amending fleet renewal conditions (maximum tolerated age) type of fuels used and vehicles' size.

Light duty trucks

Additional changes in this type of trucks have been considered. Expected performance enhancement is indicated below:

Table 42   Expected performance increases

Fuel	1995	2005	2010	2020
Gasoline lt/100km	16.00	15.05	12.30	8.30
Diesel oil lt/100km	10.70	10.56	9.30	7.14
CNG m^3/100km	17.70	17.54	14.40	10.67

A significant penetration of gas oil and CNG is expected according to the following percentages:

Table 43   Penetration of diesel oil and CNG

Fuel	1995	2005	2010	2020
Gasoline	67.1%	32.4%	9.4%	1.3%
Diesel oil	22.4%	52.6%	33.0%	28.7%
CNG	10.5%	15.0%	55.2%	63.9%
Electricity			0.2%	0.7%
Hydrogen			2.2%	5.4%

The possibility of achieving expected goals depend on regulations and legal changes imposing technical characteristics on vehicle manufacturers and an adequate pricing policy for fuels in order to favour substitution processes.

Commuting railways

As regards commuting railways switching diesel oil to electric locomotives is considered with the following impact on transported passenger-km:

Table 44   Impact of switching diesel oil to electric locomotives

Trains	Transported passenger-km			
	1995	2005	2010	2020
Electric locomotives	53.2%	74.2%	84.6%	89.4%
Diesel locomotives and railcars	46.8%	25.8%	15.4%	10.6%

Additionally the diesel locomotive fleet would decrease in number as a result of a slight penetration of CNG in railway transportation. 3% of diesel locomotives would use CNG in 2010 and 5% in 2020.

Inter-city railways

The electrification of inter-city railways has not been considered. It is possible however to think about CNG penetration in percentages similar to those presented for commuting trains, i.e. 3% of the diesel locomotive fleet working with CNG in 2010 and 5% in 2020.

2.2   Industrial sector

The industrial sector mitigation analysis aims at identifying all the technically viable options or, in other terms, calculating the potential savings regardless of its economic

feasibility. The basic assumption that justifies the scenario involves the interaction of environmental, industrial and technological policies.

It should be understood that considering environmental protection goes beyond the *end of pipe* treatment in the industrial activities. In this scenario the product design itself implies concern for energy savings and non-contaminating processes. It is assumed that these new processes decrease the need for inputs, recycle by-products and/or decrease the end treatment requirements and are also associated to productive efficiency.

It was assumed that the future evolution of energy intensities differs from that considered for the baseline scenario insofar as specific consumption's ratio in both scenarios. Thus, the mitigation scenario energy intensity will be equal to:

$$Mitigation\ energy\ intensity = \frac{Mitigation\ specific\ consumption}{Baseline\ specific\ consumption} \times Baseline\ energy\ intensity$$

Each selected branch's specific consumption shall evolve from base year values to the best state-of-the-art values, obtained from the numerous bibliographic sources available, essentially from UNIDO (Industrial Technology Inventory) that provides important information mainly on energy intensive industries.

The mitigation options assumed for each sector under analysis strength the natural trend towards higher efficiency foreseen in the baseline scenario as an autonomous efficiency improvement requiring no explicit policies. Additionally, in this scenario measures are expected to attain optimum plants' scale for maximum productivity.

Whatever the nature of options adopted for each activity, the specific energy consumption per unit of production (GJ/ton, for instance) will be used as an adequate indicator to measure the results obtained. In the following sections such indicator is used to establish the goals that can reasonably be attained in each selected branch as regards energy efficiency.

Mitigation actions may be of two different types. The first refers to the possibilities of improving energy efficiency in production processes in general through technological changes or other type of actions that shall be discussed subsequently. The second relates to the possibilities of electricity cogeneration as a mitigation option.

A brief description follows on the technical and economic characteristics of selected activities and the hypotheses assumed. The role of cogeneration as a mitigation option is presented separately and for the whole industrial sector.

2.2.1 Analysis by industrial branch

Pulp and paper manufacturing

The branch presently includes about 100 paper producing companies and 25 cellulose pulp; generating around 1.5% of the industrial GDP and billing amounts several billion dollars.

Even if pulp production is relatively concentrated remarkable technological, production capacity and age differences exist. The six major and modern companies account for 65% of pulp production. The paper sector evidences similar characteristics where 7 companies account for 50% of production.

The technology used in the pulp and paper industry has not undergone excessively dynamic developments lately. Two basic processes are used called chemical pulping and mechanical pulping. According to the desired paper characteristics, the type of fibre is combined with a type of process and the following pulps are obtained: Kraft, sulphite pulp; mechanical pulp; thermo-mechanical pulp and chemi-thermo-mechanical pulp.

Paper production can be divided in two stages:

• primary transformation, based on different pulp combinations, with various sequential stages and high energy use, and
• secondary transformation, where the base paper obtained in the previous stage is transformed in paper for various purposes with the relevant use of different chemical products.

The technical innovations induced by environmental requirements can be summarised as follows:

• Cellulose paste: Reduction of chlorine content in the products; process and end-of-pipe management to decrease emissions into the atmosphere and water streams.
• Paper: Reduce residual chlorine content, purify fluid effluents, increase recycling to prevent pressure on native forests and decrease the solid waste volume.

This industry exhibits a low vertical integration and remarkable low scale plants. (New plants established around the world have a minimum scale of 200/300000 tons per year and the new paper producing machines have capacities of 150/200000 tons a year). The capacity ratio was 1 to 4 with Brazil and 1 to 10 with the U.S., Canada, Scandinavian countries and Japan. Such situation places our industry in a disadvantageous competitive situation.

The branch offers a number of opportunities to increase energy efficiency. The following can be included among those of a general nature:

• Boilers' operation enhancement
• Heat recovery from Boilers' exhaust gases
• Condensate return
• Pipes and ducts thermal insulation
• Installing economisers or air pre-heaters in boilers
• Using varying speed motors
• Replacing steam ejectors by vacuum pumps
• Obtaining flash steam from high temperature condensates

As for specific opportunities, the following can be mentioned:

• Enhancing hot air supply installations in paper producing machines
• Savings from "white" water pre-heating
• Heat recovery from flashing furnaces
• Streamlining calender's operation

- Increasing the use of "black liquor" as a boiler fuel
- Elimination of starting up steam over-consumption after paper breaking in paper machines
- Safety valves automation for cases of steam over-pressure caused by paper line interruptions
- Recovery of vented steam when paper breakage occurred in paper machines
- Savings in filtered water
- Adjusting digestor's steam supply pressure
- Use of mechanical press in some paper machine areas
- Increasing liquor concentration
- Liquor heating using low instead of medium pressure steam
- Heat recovery from "cooking" waste fluids
- Streamlining the mechanical press process to eliminate water
- Use of infrared rays in the drying process
- Paper machines computerised control and regulation

This activity's specific consumption amounted to 32 GJ/Ton of paper in 1995. However, according to international information[32] the state-of-the-art expected for the year 2010 anticipates 26 GJ/Ton and only 19 GJ/Ton by the year 2020 when an advanced technology still under development became available.

Such values indicate that the specific consumption may decrease at an annual rate of 1.37% until 2010 and then some 3% annually until 2020.

This branch might attain the performance internationally expected for the year 2010 and 2020 if the above mentioned actions are implemented and a significant increase in plant scales occurs provided the market conditions allowed for it.

Cement, lime and gypsum elaboration

Cement consumption per inhabitant in Argentina is very well below Australia's 681 kg/inhabitant (the highest) or Mexico's 330 kg/inhabitant. Such sector accounted for 3.82% of the domestic industrial value added.

Only the dry process is used in Argentina to produce cement. Even if different technologies coexist; in all of them the raw material humidity at the furnace entry —or at the preheating system— must be below 1%. Such process' thermal performance is the highest, achieving a specific consumption under 3.349 MJ/kg of clinker.

From the standpoint of energy savings, limestone drying and grinding, clinker manufacturing and grinding and silage are the most attractive stages of the process.

The cement industry highly expanded its installed capacity in the eighties, on account of substantial growth expectations from the construction sector that did not materialise. At the end of the decade cement companies were working at 35% of their capacity. Such circumstance suggests that mitigation options should be related to process improvements rather than to the construction of new plants with revolutionary technologies which, on the other hand, have not appeared. In addition, it should be

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[32] UNIDO/SEI, Industrial Technology Inventory - Vienna, 1997

noted that the technological standard of cement factories in Argentina is quite acceptable.

Among energy saving alternatives, one should consider the adoption of "flash" pre-calcination. Such reaction in the rotating kiln absorbs over a half of the heat provided for clinker production. The incorporation of the flash stationary kiln allows for the use of relatively short rotating kilns, which require half the calories than conventional ones. Specific energy consumption achieved with this modification permits to reach very low values in the dry process.

Another important improvement refers to energy savings in combustion, to be achieved through:

- Regulating the primary air-inflow to the kiln burner.
- Flame control. In order to ensure good conditions in the shape, glow and radiant power the right amount of air should be guarantied.
- Using the clinker cooler exhaust gases for secondary burners' combustion.
- Recycling the flying ashes with high content of non-burned elements.

Other potential measures, some of which are being adopted in certain Argentinean factories, are:

- Using suspension pre-heaters.
- Reducing the electricity consumption with clinker pre-grinding systems and roller presses, with about 30% of electricity savings.
- Using second and third generation screening plants to select the size of cement particles with greater efficiency, permitting to recycle only rejected particles.

As for the incorporation of new technologies the use of fluidised bed cement furnace shall be studied, which consists in a bed furnace for hot auto granulation of cement and a fluidised bed furnace for clinkering to strictly control temperature.

Compared to the rotating kiln with suspension heater, the new furnace has the following advantages: higher heat recovery, larger fuel flexibility, decreased pollution, flexibility to produce special cements, less heat losses, increased plant productivity, lower investment, reduced engineering costs in the installation, operational and maintenance ease and simplicity.

It should also be pointed out that with a high efficiency particle sorter up to 25% electricity can be saved in finish milling, which account for 31% of the electricity used. The short rotating kiln uses only 50% of the energy used by conventional furnaces.

In the base year, this activity's specific energy consumption reached 7.1 GJ/Ton. Using the new technologies (pre-calcination techniques and short rotating kilns), the state-of-the-art specific consumption would be 3.56 GJ/Ton of cement for year 2010 and 2.34 GJ/Ton in the year 2020 [33].

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[33] US Country Studies/Lawrence Berkeley National Laboratory, Greenhouse Gas Mitigation Assessment: A Guidebook, 1995

Cattle slaughterhouses and meatpacking plants

The number of existing facilities is about 160. The slaughter of cattle amounted to 10,100,000 heads in 1995. Some 85% of them is delivered to the domestic market. The exporting-oriented industry accounts for 25% of beef production, 60% for foreign market and the rest for domestic consumption, as meat and manufactured products.

There are about 30 integrated facilities (slaughter and processing) and a lower number of processing plants, which account for total exports.

Exporting meatpacking plants have undergone substantial technological development especially as regards health and safety and laboratories. The major Argentine exporting market is the European Union.

Production processes differ according to the specialisation degree of the facilities. In general, in an integrated facility the following are included: slaughter, cooling, quartering, selecting and packing line, packaging, cooling or freezing, storing and transportation.

The exporting segment is permanently renewing technologies, looking for new products or processes to favour a higher foreign markets penetration and to a lower extent, for the local market. The beef exporting industry technology complies with international standards.

Increases in productivity and energy efficiency shall be oriented to the vast majority of the facilities, which have not yet devoted to investment and modernisation.

Except for the integrated meatpacking plants that export their production, all measures aimed at promoting rational use of energy can be implemented, as immediate and short-term actions. In the long term, demand-driven capacity expansion should allow for incorporating new technologies and processes suitable to final markets' requirements.

As the activity is so heterogeneous, given the number and diversity of facilities, specific consumption values should be taken as averages. In 1995 specific consumption amounted to 3.55 GJ/Ton of beef. Such specific consumption, according to technical literature could decline to 1.75 GJ/Ton in 2020. The decline in specific consumption would occur at -2.79% per annum throughout the period, considering that technical improvement possibilities are substantial.

Vegetable oils and fats

The oil industry is major in the country. The capacity installed for seed processing exceeds 14 million tons, not always fully used. Facilities devoting to such activity exceed 80 in number and are owned by about 40 companies.

More than a half of the existing facilities apply extraction procedure using solvents and the rest are divided between solvents combined with presses and continuous presses (preferably used for linseed oil).

There are also about 10 facilities devoted to vegetable margarine refining (approximately 400 Ton/day) and 7 hydrogenated product's factories (200 tons/day).

The foreign market is the major oil production recipient, purchasing three fourths of the production. Likewise, exports also drive oil seed production in the country, as most of local production is exported as grain itself, oils or by-products.

During late years significant changes occurred in industrial plants, both in number and production scales. These movements included the following aspects: technology renewal, product specialisation, higher vertical integration, a more concentrated production and changes in ownership.

Since the eighties substantial investment has been made in the country to establish new plants fitted with modern international technologies.

In oil extraction by pressure the grain is dried with hot air, then ground, milled and boiled. Thus raw oil is obtained which can then be processed in refineries. The solid product obtained by pressing is called *expeller*. By combining pressure with solvent the percentage of oil remaining in the expeller is extracted in amounts ranging between 14 and 20%. After pressing the residual flour becomes *pellet,* which is mainly used in prepared feeds.

The process comprises the following stages: preparation, extraction and ancillary processes, solvent removal from the flour, preparation of the flour, distilling of miscellas, dissolvent recovery.

Three major supplies are required in this industry: steam, water and electricity.

The steam is mainly used in the flour desolventiser toaster (DT). The volume used depends on the amount of solvent to be evaporated and the amount required for treating the flour. The economies sought can be the following:

- Use a steam economiser in distillation, i.e. a heat exchanger that uses the waste heat of exhaust gases from the DT for the first vacuum evaporation of the solvent contained in the extraction miscella.
- Use the latent heat from the DT's exhaust gases after their passage through the economiser to heat the dissolvent.
- Re-heating of miscella.
- Concentration of absorption oil.
- Recycling used water.
- Reducing the steam requirements by systematic steam injection division.
- Reducing the water flow by using serial surface coolers.
- Using fluid drive to decrease installed capacity.

In 1995 the average specific energy consumption for the whole branch reached 7.95 GJ/Ton and 5.00 GJ/Ton are expected for the horizon, assuming a -1.84% annual decrease throughout the period.

The high 1995-average specific consumption results from the coexistence of large facilities using up-to-date technologies and having low energy consumption together with some facilities using obsolete technologies.

The estimated average energy consumption for the year 2020 could only be attained reducing the present technological differences between facilities and provided the new facilities adopted the best technology internationally available at any moment.

Dairy products
This industrial branch includes milk, cheese, butter, caramel, casein and yoghurt production. Production is very highly concentrated in a small number of companies

whose production is mainly sold in the domestic market. There are also a large number of small regional companies whose number is clearly decreasing.

The sector accounted for 1.8% of the 1995 industrial GDP. Milk production amounted to 8528 million litres in 1995. Exports from the dairy sector mainly rely on powder milk and secondly on cheese, although such ratio changes on a yearly basis.

In the milk and yoghurt sector productivity is high and competitive with more developed countries. In cheese production companies using modern technologies (with a high capital/product ratio) interact with others working practically at handcraft levels.

The dairy products having the highest specific energy consumption are powder milk and cheese.

The average specific energy consumption for the whole branch had to refer to the mix of items produced (fluid milk, powder milk, cheese, etc.). Such value amounted to 2.97 GJ/Ton of mix in the base year. For the year 2010 the state of the art consumption was estimated in 2.07 GJ/Ton, with a decline rate of -2.38%. Most energy saving measures should concentrate on cheese production.

Estimates assume the technological homogeneity of the sector's companies, namely levelling the large companies' technologies, which are expected to remain close to the state-of-the-art standard.

Textile fibre yarn, fabrics, finishing of textile products

The branch's value added gradually decreased its industrial GDP share to 10.4% in 1995. However, such activity is still relevant in the manufacturing industry and its previous potential may revive as soon as the restructuring increase its competitiveness.

Total yarn production reached 57,000 tons in 1995. In fabric production the following shares illustrate the structure that makes up the final figure:

1. Cotton fabrics and mixes   69%
2. Woollen fabrics and mixes   16%
3. Monofilament fabrics   15%

In the cotton sector, cotton gins owned by vertically integrated companies are highly technified and efficient. There are, however, other facilities owned by producers and/or co-operatives whose technologies are obsolete and performance is very low. Spinning and weaving is highly concentrated and works at good technological standards.

The wool sector is composed of a large number of laundry shops with obsolete technologies and low performance. Some however, owned by vertically integrated companies, have modern technology and high performance.

The textile activity is structured through various basic inputs: cotton, wool, man-made and synthetic fibres and other natural ones (sisal, jute, hemp, etc). Three types of businesses originate from such inputs: cotton, wool and other textile fibres-related activities.

Cotton-related textile activity is more relevant than wool and accounts for over 65% of textile production gross value.

In the cotton productive chain the first process is the cotton gin, where cotton is separated from the seed.

The process to obtain the cotton yarn and its mixes with other fibres is highly complex. We shall only mention the various stages involved in such process:

1. opening of bales, mixing pulls and removing trash;
2. carding;
3. obtaining "tops" in the flyer frames;
4. dying;
5. "continuous", where the yarn is obtained;
6. dyehouse, where the yarn arrives in cones, bobbins, quills, warp folder, etc.

Yarn is fabrics' basic input. Eyelet weavings or flat woven fabrics use looms, either automatic or semiautomatic shuffle loom; in some looms the weaving is done with steel or plastic projectiles, or with drops of water expelled with force. Such looms are growing in number, replacing the shuffle looms.

The wool chain starts by washing the wool, once it has been classified in three categories: thin, thick and mixed wool. Then follow the drying, dyeing, spinning and weaving processes.

Cotton yarn consumption amounted to 96,000 ton in 1995. About 30% of the wool production goes to spinning shops.

Acrylic fibres rank first among manufactured fibres, followed by polyester.

Given the conditions of most of the businesses devoting to such activity, an important savings potential is perceived therein.

Firstly, general measures to promote rational use of energy are applicable in the short and medium term, referred to machines and equipment maintenance, functioning of boilers, variable speed engines, etc. As for capacity expansion, new plants are expected to incorporate last generation technological advances.

Among specific measures to be taken the following should be mentioned: the vacuum dyeing system using 22 to 75 kW pumps and requiring 30/50% less energy than conventional systems. Electricity shall be broadly used in future increasing its share by 1%.

For this sector too, specific consumption should refer to a "product mix" of all the activities contained therein. In 1995 the average specific consumption was 34 GJ by Ton of mix with high dispersion due to the number of existing facilities and their diversity regarding technology and maintenance.

The estimated average specific consumption for year 2020 using the state of the art technologies at that moment is 19 GJ/Ton, i.e. a regression rate of -2.3% per annum during the whole period.

It should be pointed out that such specific consumption regression rate does not result from the adoption of a certain technology in itself, but from modernisation, technification and state-of-the-art acquisition in the sector.

Remaining industries

It would be very difficult to explain potential changes in energy consumption on the basis of specific consumption, as for heterogeneous activity groups it would make no sense to add up physical production units. It was therefore decided to operate on energy intensity values directly.

As explained in the baseline scenario, the "remaining" industries in the manufacturing sector involve 66 activities, 7 of which are grouped in the remaining energy-intensive industries and 59 in another non energy-intensive group.

As for the remaining energy-intensive industries, attempts were made at measuring prospective energy savings above those analysed in the baseline scenario. Under such conditions it was estimated that the energy intensity of the remaining energy-intensive activities could decrease 24% in 2020 compared to baseline values. As for the remaining non energy-intensive industries, energy intensity would decrease 37% by 2020 compared to baseline values.

2.2.2 The role of cogeneration

Cogeneration, joint production of electricity and heat, involves two types of energies: mechanic, with the possibility to be transformed into electricity and heat. Generally, it is in the large industries where both energies became evident[34].

Cogenerating systems produce no reduction in the required useful energy, but use less energy to supply the same energy service.

Cogenerating systems are mainly classified in schemes:

1. **"Topping"** where combustion's primary product is electromechanical energy and waste heat is used in the productive process. Food, paper, textile, oil industries, are the most suitable to apply such technology. Maximum temperatures reach 500°C. Equipment used may be gas or steam turbines, combined cycles or internal combustion engines.

2. **"Bottoming"** where energy is first used for heat in the industrial process and then used to generate electricity (ceramic or metallurgic blast furnace). Waste energy is generally collected in a recovery boiler and, when not required for the industrial process, is used for electricity generation. In the recovery boiler, convection heat transfer predominates.

The efficiency of a cogeneration plant is higher than any other devoting exclusively to one process or the other, ranging from 60% to 85%. Being a highly efficient energy technology, it was considered as an additional mitigation option

In order to define the technical cogeneration potential, activities requiring both electricity and heat in their processes were selected as candidates for cogeneration. Among the different criteria that can be used to select potential cogenerating activities, the one based on the **Energy Coefficient (R_1)** was chosen due to the high aggregation level of available information. Such coefficient is defined as the ratio between heat and electricity demands (both of them expressed in the same energy unit) and may indicate the technical attractiveness of a cogeneration facility.

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[34] However, potential for cogeneration may exist whenever large heat and electricity consumption and/or production are concentrated in a single location. Therefore, the services (hotels, hospitals, hyper-rmarkets, etc) and residential (condominiums) sectors should not be excluded of future works.

176

According to such ratio industries can be classified in heat-intensive or electricity-intensive activities. A deeper analysis could however show that within the same type of industry the index range is quite broad, and even in one plant variations exist depending on the time, season, etc.

The specialised literature states that industries can be classified according to R_1 values as follows (Table 45):

Table 45   Classification of industries by Energy Coefficient

Electricity-intensive	$0 < R_1 < 2.5$
Intermediate intensity	$2.5 < R_1 < 11$
Heat-intensive	$11 < R_1 < 100$

Electricity-intensive industries are those with high electricity consumption and very low heat consumption, not considered as potential cogenerators. On the other hand, intermediate industries are considered as pure potential cogenerators whereas heat-intensive industries are potential surplus suppliers to the grid. It can then be noted that when considering only the heat/electricity ratio (R_1) almost all industrial branches, and even some services, can meet, at least partly, their energy demand through some of the above described cogenerating systems.

Each generating technology (TV, TG and diesel) is also characterised by a particular ratio between the waste heat and electricity generated (R_2).

Gas turbines, just like internal-combustion engines, through a recovery boiler allows for using the waste heat of exhaust gases in the industrial process otherwise released into the atmosphere at high temperature. They adapt to systems with heat/electricity ratios ranging between 2.0 and 4.5. Back-pressure-steam turbines are especially suitable when thermal energy consumption is high compared to electricity ($4.5 < R_1 < 6$). Although flexibility exists with regard to the type of fuel, the steam production/power generation ratio is tightly defined.

When the electricity required exceed heat demand, some low-pressure steam is extracted at points on the turbine to supply heat for the industrial process. Most of the steam is expanded in the turbine and then goes through the condenser where a certain amount of heat is released to the environment, thus decreasing the system's efficiency.

Table 46 illustrates R_1 mean values for various Argentine industrial sectors[35] and the appropriate cogenerating systems.

Table 46 R_1 values and appropriate cogenerating systems

Industrial branch	R_1=heat/electr. ratio	Suitable cogeneration system
Oils	3.5	Steam turbine
Meatpacking plants	3.2	Steam turbine
Dairy	4.1	Gas turbine
Textiles	2.6	Steam turbine
Cellulose & paper	4.6	Steam turbine
Iron & steel	5.6	Steam turbine

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[35] "Análisis Comparativo de Consumos Energéticos en Sectores Seleccionados: Argentina, Brasil, Paraguay y Uruguay. País: Argentina" IDEE/FB, December 1993.

As can be noted, the cogenerating system proposed in the table for each manufacturing activity may be different from the system that in theory maximises the overall energy efficiency of the process considering only the R_1 ratio. Taking the vegetable oil manufacturing as an example, according to its R_1 ratio (3.5) the best cogenerating system would theoretically be gas turbines. However, steam turbines are proposed in the table, as the industrial process needs steam.

Therefore, the R_1 ratio is only indicative to chose the cogenerating system, as a deep analysis will be necessary in each particular case to define the proper system.

All the manufacturing processes in Argentina were analysed to search for those activities using steam and/or direct heat in the industrial process as candidates for cogeneration. For this searching "The Energy Analysis by 108 Industrial Process" by Harry L. Brown, Bernard B. Hamel and Bruce A. Hedman was used, and it was proven that only 6 industrial divisions used steam and/or direct heat. Such divisions are 31 (food products), 32 (textile), 34 (paper and paper products), 35 (chemical products) and 37 (basic metal, partially).

The industrial branches under analysis in the present study are potential cogenerators and in such sense hypotheses have been developed on cogeneration's penetration in total electricity consumption. One of such hypothesis was that cogeneration may penetrate easily in those manufacturing activities requiring steam for the industrial process and having some generating capacity already installed for electricity self-generation. Thus, some meatpacking plants, vegetable oils producing facilities, dairy-products manufacturing plants and pulp & paper manufacturing facilities proved to comply with both conditions (being steam demander and electricity self-producers). In such cases, existing electricity generating facilities were assumed to be reconverted into cogenerating facilities in the future. It should be noted that the aggregation level of available information on industrial self-generation prevented to identify those facilities that already correspond to cogeneration, but they have a low share if any.

Among potential cogenerating industries attention has been paid to those whose production process generates wastes that could be used as fuel. At present most industries give some economic use to such wastes and in many cases they are used for electricity self-production in open cycles. Burning productive wastes in a cogenerating system (whenever it proved to be more profitable than the current uses) would permit to further increase the production efficiency. Besides preventing the purchase of alternative fuels and the transportation of wastes for other uses, the joint production of heat and electricity has a higher efficiency than supplying them separately. Some Argentine agroindustries, e.g. sugar mills (as part of energy-intensive industries), rice and grain mills (non energy-intensive remaining group) vegetable oil producing facilities, lumber yards, paper industries, etc. produce substantial wastes both in volume and energy content.

For those branches having seasonal waste availability, natural gas has been assumed in this mitigation scenario as the alternative and most convenient fuel. Hypotheses adopted appear in Table 47.

It should be pointed out that both sugar mills within the branches grouped as remaining energy-intensive industries and agroindustries within the remaining non energy-intensive are included as potential cogenerators.

Table 47   *Electricity consumption (10^6 Gigajoules) and cogeneration percentage per module*

Branches	Sources		1995	2005		2010		2020	
	NG	Wastes	Electr.	Electr.	Cogen. %	Electr.	Cogen. %	Electr.	Cogen. %
Meatpacking plants	X		2.08	2.84	2.11	3.18	1.89	3.61	2.49
Dairy	X		1.85	2.29	1.31	2.58	1.20	4.31	1.90
Oils	X	X	3.11	3.80	13.95	4.44	15.10	6.27	17.90
Textiles	X		3.85	3.83	0.52	3.40	0.60	3.92	0.50
Pulp & paper	X	X	3.44	4.72	35.17	5.80	35.90	7.90	36.00
Remaining energy-int.	X	X	41.86	52.54	11.90	62.75	14.30	89.06	14.30
Remaining non energy-intensive industries	X	X	32.30	42.75	1.89	49.93	1.80	69.69	1.90

As above mentioned, due to insufficient information it has not been possible to separate, within the branches considered, self-production from the cogeneration that is presently materialising. In such sense it can be noted that in 1995 no cogeneration percentage is presented, whereas starting in 2005 all potentially cogenerating branches exhibit such percentage within a broad range.

In 2005 the following prevail:

- The pulp and paper branch, where cogeneration accounts for 35.17% of total electricity consumption (4.72 millon GJ).

- The remaining energy-intensive industries with approximately 12% of electricity consumption (52.54 millon GJ) supplied by cogeneration, exhibiting the highest growth rate (7.5% annually) by 2010.

By 2020, both pulp and paper and the remaining energy-intensive industries maintain cogeneration's share in electricity consumption with 35.95% and 14.28%, respectively, although in both cases the growth evidences a downward trend. The highest growth rates (2010/2020) occur in the dairy and vegetable oils industries with 10.3% and 5.3% annually associated to production increase in such activities.

Distributed gas and other primary energy sources (biomass wastes) are used in different proportions in each module.

2.3   Mitigation options in energy supply

Power stations together with fugitive emissions from the gas industry presently account for 70% of carbon dioxide emission originating from energy supply-related activities. The remaining 30% results from fuel combustion to meet the oil and gas industry energy requirements (energy sector's own consumption).

As these two activities exhibit a similar share (70%) of total methane and NO_x emissions, for the sake of this study the mitigation options focused on the electricity industry and on controlling the natural gas industry's fugitive emissions.

Natural gas fugitive emissions

It should be made clear that according to the GHG inventory report for Argentina, methane fugitive emissions accounted for about 74% of this gas' total emissions from the energy system and 98% of those resulting from energy supply. The key element for such results was the assumption that natural gas vented in gas fields was not burnt in flare and was therefore released into the atmosphere as CH_4.

However, a more careful search for data on venting modalities in each gas field showed that the assumption adopted for the GHG inventory was incorrect. Firstly, about 80% of the vented volume correspond to a 60/40 mix of natural gas and dissolved carbon dioxide. Therefore, and regardless of whether vented gas is burnt in flare, about 32% of the total vented volume would be released into the atmosphere as CO_2. Secondly, data collected for 1994 show that about 90% of such volume is burnt in flare and only 10% is directly released.

As a result of such data, methane release to the atmosphere from gas venting would decrease to below 7% of the total vented volume. For the sake of this study, such hypothesis was adopted with regard to the effects of natural gas venting in gas fields to replace the one appearing in the national GHG inventory.

Under 1995 field operating conditions, even considering such hypotheses, CH_4 emissions from gas venting broadly exceeded methane fugitive emissions in natural gas transportation and distribution. Therefore, and from the climate change mitigation standpoint, options to decrease gas venting in fields would seem a priority.

However, in 1993 the energy authorities already took measures to attain such goal, replacing the regulations that had been current since 1979. Under Resolution N° 236/93 of the Energy Secretariat a transition period was defined to decrease gas venting in the so-called oil wells (gas/oil ratio under 20000 m³ of gas per m³ of extracted oil). It should also be made clear that gas venting is totally banned in wells with a gas/oil ratio exceeding the above-mentioned figure (gas wells).

According to such regulations the goal for the year 2000 is not to exceed 1 m³ of gas vented per m³ of extracted oil, except for cases being granted special permits by the Energy Secretariat. Full compliance with this regulation would bring down present venting indexes, 10% of natural gas production, to 2% at the turn of the next decade.

Being this stringent regulation already in place and its effects included in the baseline scenario, no additional actions have been considered in the mitigation scenario to control emissions from gas venting. However, as noted when discussing resulting emissions, the new regulations are clearly a climate change mitigation action already implemented in the country at its own cost, although Argentina, as a non-Annex I country of the Framework Convention on Climate Change, is not compelled to take such measures.

In spite of the decision made in this study regarding the exclusion of mitigation options related to fugitive gas emissions' control, it should be stated that some national oil companies are analysing the technical and economic viability of capturing part of the CO_2 released from natural gas venting.

Although the possibility may seem attractive, the impact of such projects on total carbon dioxide emissions would be highly restricted by the dramatic decrease expected in total vented volumes. Consequently, and given the general nature of this study, such projects have not been considered as mitigation options to build the scenario, without it implying any judgement of value about the viability or convenience of their effective implementation.

Options in the electricity industry
In very general terms the electricity industry could resort to three different types of mitigation options:

180

- replace fossil fuels for other energy sources in electricity generation
- improve the heat rate in thermal power plants, and
- reduce electricity transmission and distribution losses.

Reducing distribution losses, which had reached extremely high values, is electricity distributing companies' explicit goal to improve their economic equation. Actually, some of the country's major distributors succeeded in attaining such goal.

To the extent that companies' own economic interest drives them along such road, no explicit intervention by the public powers would seem mandatory to achieve a higher distribution system efficiency, beyond having established a 14% maximum loss to set electricity retail rates.

On the basis of such considerations, it was estimated that the distribution losses' decrease would naturally be attained in the baseline scenario, with the achievements described in Chapter VI, and that no additional measures would be required to promote such path.

Losses' standards for the extra high voltage network have always been reasonable in the country and in keeping with generation and load spatial distribution. On the other hand, as losses affect the prices each agent collects and/or pays for electricity taken from the grid, it is the agents' economic interest to decrease as much as possible high voltage losses. Consequently, in this case again no mitigation options aimed at decreasing transmission losses have been analysed.

As for opportunities drawn from improving heat rates in thermal power plants, the reasons that gear electricity generators' decisions to opt for the most efficient technologies internationally available have been extensively explained. Likewise, the major and exclusive role of natural gas would leave no space to encourage a higher substitution of petroleum products and coal, practically unused in power plants.

As a result of such considerations and for the sake of the present study, it was estimated that the only mitigation actions with a noticeable impact on GHG emissions are switching fossil-fuelled plants to emission-free technologies. Within such category, three technologies were analysed: hydropower, wind and nuclear generation.

Over a theoretical hydroelectric resource of 170 TWh/year, calculated as a function of national hydrographic basins' slope and flow, it is estimated that the technically available resource in Argentina would amount to 130 TWh/year, of which only 25% are currently being used. It could be then stated that power supply strategy of private generators lies on strictly economic bases and is not conditioned by the lack of hydroelectric resource.

Within the menu of hydropower developments that could be built in the country, the only ones that could undoubtedly contribute massive hydraulic generation are those located in the del Plata basin, especially on the Parana River. Such projects underwent innumerable technical and economic studies in the past. However, changes in the electricity industry organisation in 1992 substantially affected the decision parameters to invest in their construction.

Few hydropower projects have been reassessed considering the new context defined by the electricity industry reforming. From such studies the power plants' basic designing parameters were changed, not only regarding building techniques to shorten

construction times and decrease costs, but also in power plants' generating capacity and their ability to produce non-firm energy.

On the basis of such considerations, 3 projects on the del Plata basin were selected as the most viable. Two of them located in international sections of the river, and therefore to be shared with the respective neighbouring country, and the third one in the national sector of the Parana River. Three projects on the Bermejo river were then added, not on the grounds of their energy relevance but because Argentina and Bolivia have already reached an agreement to promote their construction.

Even when international projects would require specific agreement between the countries involved to materialise their construction, this would not become an insurmountable obstacle within the MERCOSUR growing energy integration. Actually the eventual partners (Paraguay and Brazil) have evidenced their ongoing interest in building the works.

Countries in the region have gained some experience in entering into this type of agreements as 3 binational hydropower stations were already built on the del Plata basin. However, the agreed terms should switch from governmental liabilities to laying the grounds for the general rules to be respected by private investors responsible for building and operating such undertakings, overcoming the challenges posed by different national regulation and institutional arrangement for the electricity industry.

In the case of the national project on the Parana River, some foreign investors have expressed their interest in analysing building possibilities. Although such initiatives have not prospered, it was considered that private investors' interest could be attracted through the right promotion measures.

In summary, to the effects of the present study, the possibilities to increase hydroelectric generation in the mitigation scenario would rely on the construction of the following power stations:

- HPP Corpus: 2880 MW and 19000 GWh mean annual generation. The whole production would go to the domestic market: 50% as local generation and 50% as imports.
- HPP Garabi: 750 MW and 3300 GWh mean annual generation. The values account for 50% aimed at the domestic market.
- HPP Parana Medio: 3000 MW and 18600 GWh mean annual generation.
- Full development of the Bermejo River: 280 MW and 1330 GWh annual generation.

As for the nuclear option, it should be mentioned that in Argentina the first nuclear power station started functioning in 1974 and since 1982 the nuclear supply amounts to 1018 MW with good availability and utilisation factors. The works of the third nuclear power station (740 MW) are practically interrupted, but according to the Energy Secretariat's forecasts, based on the 1997 Prospective study, such works will proceed and the power station will hopefully start operation in 2004.

Public perception with respect to the nuclear option has changed since the Argentine nuclear plan was launched in the late sixties, involving the installation of 10 power stations. Such changes mainly refer to final disposal of irradiated material, rather than to the risks of the power stations' operation, as to date no severe incidents involving nuclear hazards have been made public.

To date, irradiated burnt elements are stored in basins inside the power plants. The Nuclear Energy Commission started studies to define suitable locations to be used as nuclear waste final repositories. When possible sites became known, public protests arose mainly from the towns located close to such sites.

Recently a new federal act was passed to regulate nuclear activity with a view to privatise existing power plants. Although the occasion marked the beginning of a debate around the nuclear issue, nuclear power plants' privatisation and related safety problems prevented a thorough public debate from taking place, on the convenience and acceptability of maintaining the nuclear option for electricity supply. Such debate is still to take place. Particularly the global warming problem was not even mentioned as one of the aspects to be borne in mind when defining the country's nuclear policy.

However, the economic feasibility of nuclear power plants after the power sector reforming is doubtful and this option is opposed by certain groups, some concerned by the risks of severe nuclear incidents and others persuaded that gas availability turns unnecessary to opt for a much more expensive and hazardous technology.

Recently some local experts in nuclear power stations started to analyse the advantage of developing hybrid nuclear power plants, forming gas turbines/nuclear plants combined cycles, as a mechanism to improve nuclear technology's economic feasibility.

Within this context and for the sake of the present study, it was decided to keep the nuclear option open in the long term so as to facilitate the massive substitution of conventional thermal generation and prevent electricity supply from becoming highly exposed to hydraulic contribution's ups and downs.

On such basis the need to install 3 nuclear power stations was defined, besides the one presently under construction, towards the end of the period under analysis. It was originally assumed these stations would have similar features to the one under construction (740 MW).

Such assumption does not imply turning away from new nuclear technology developments, freezing the state-of-the-art on the date the power station under construction was leased. It only tends to define the total power to be installed in nuclear stations.

Particularly as regards the possibility of installing hybrid nuclear stations as the ones presently being analysed, the assessment of technical features and costs is only beginning and this study shall only define the contribution of pure nuclear generation, as a GHG emission-free technology. However, the possibility that such contribution be made from hybrid power stations is open as in the mitigation scenario the need to incorporate conventional thermal stations was detected.

As for wind generation, it should be stated that Argentina possesses substantial wind resources, especially in Patagonia, and that presently some experiences have been made installing wind turbines connected to the grid. In general such experiences were made by electricity co-operatives, which in spite of being connected to the national or regional system, receive energy from the market at very high transmission costs.

For the sake of this study it was assumed that in the mitigation scenario such experiences would expand in the future, restricted however to areas where the resource is more abundant and to small isolated systems. For large consumption centres' supply, hydroelectric and nuclear massive generation options were chosen.

On such basis it was assumed that wind generation could supply 10% of the demand in the Southern Patagonia system, 5% of the Patagonia wholesale electricity market and 3% in isolated systems. This would mean installing about 80 MW in wind turbines.

3 The final consumption in the mitigation scenario

The following sections describe the new projected energy consumption from end-use sectors, namely transportation and industry. Changes in energy own-consumption from energy supplying industries and total aggregate values are also provided.

3.1 Transport sector

As a result of hypotheses assumed and guidelines defined for the scenario, the LEAP model exhibits the consumption showed in Table 48 for the entire sector.

The average annual growth rate amounts to 3% for the whole period and CNG retains the highest growth rate.

The dynamics assumed for the various subsectors in different periods generates uneven growth rates for each of them when considering the whole prospective period. While the urban passenger transportation evidences a 2.55% annual rate, the energy consumption from interurban passenger transportation grows to 1.94% annually and the freight transportation to over 3.35% per annum, becoming the most dynamic sector as in the baseline scenario.

Table 48   Energy consumption for transportation

Source	1995		2005		2010		2020	
	Mill GJ	%	Mill GJ	%	Mill GJ	%	Mill GJ	%
Diesel oil	249.54	48.0	330.65	52.9	390.21	52.0	582.75	53.5
Gasoline	211.00	40.6	179.66	28.7	149.81	19.9	98.77	9.1
CNG	35.01	6.7	86.00	13.8	171.15	22.8	336.49	30.9
Kerosene/JP	22.58	4.4	26.34	4.2	28.80	3.8	34.86	3.2
Fuel oil	0.38	0.1	0.87	0.1	1.15	0.2	2.01	0.2
Electricity	1.25	0.2	1.77	0.3	3.86	0.5	8.08	0.7
Hydrogen					6.19	0.8	27.07	2.5
TOTAL	519.75	100.0	625.28	100.0	751.17	100.0	1090.04	100.0

Figure 47   Total consumption by transportation subsector
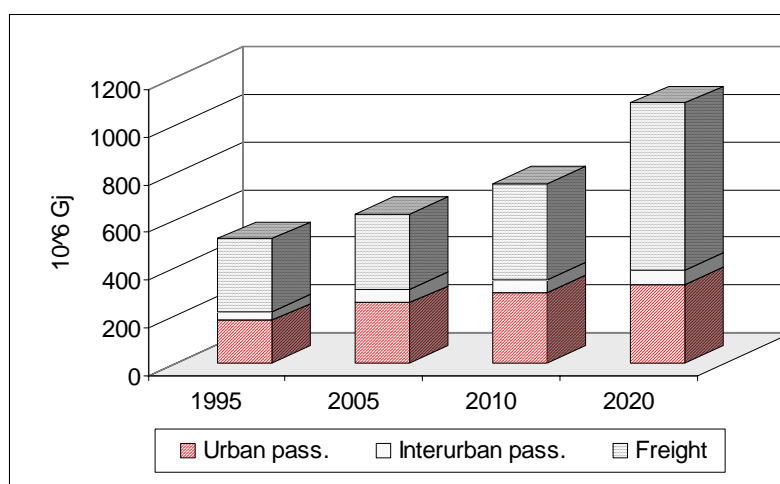
3.1.1 Urban passenger transportation

The mitigation scenario means a 9.3% reduction in 2010's total consumption and almost 20% in the year 2020 when compared to baseline scenario values. Besides such drop in total consumption, a significant decrease of almost 32% occurs in petroleum products in 2020, due to electricity, hydrogen and CNG higher penetration.

Total energy consumption from this subsector, reaching 329.31 million GJ, accounts for 30.2% of the total energy consumption for transportation in 2020, and for 96% of the gasoline used by the sector

Private cars retain its pre-eminence with almost 72% of the sector's consumption. The share of exclusive rail means (Railways and Subways) grows, accounting for 1.8% in 2020.

CNG becomes the predominant source (41.4% of the sectoral consumption in 2020) while gasoline rank second. Hydrogen accounts for 0.8% of consumption in 2010 and 3.1% in 2020 and electricity grows to 1.8% in 2020.

In spite of implementing mitigation options, the subsector shall still rely on non-renewable energy sources and petroleum products will maintain their predominant role (53.7%). However, gas penetration allows for substantial diversification and involves a positive effect on the subsector's specific emissions even when private cars still accounts for the largest figures (73% of the subsector's consumption).

Figure 48   Urban passenger transportation. Consumption by source and transportation mode
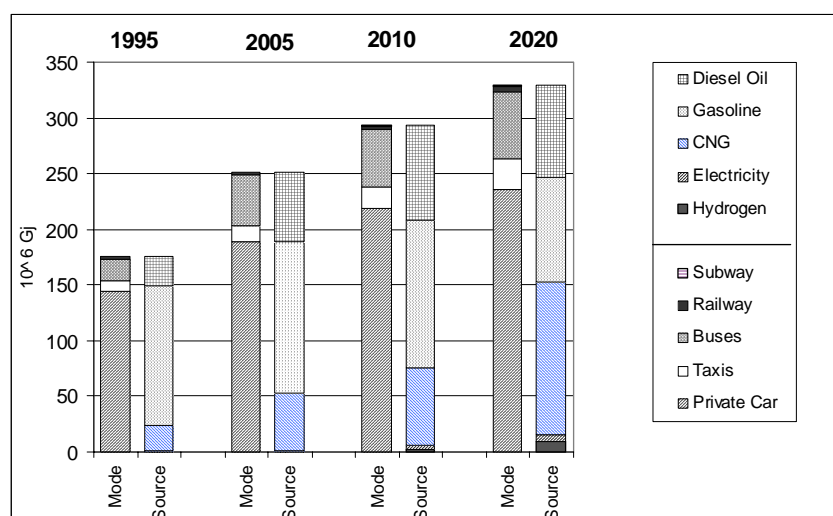

3.1.2 Interurban passenger transportation

The subsector's total consumption drops by almost 12% compared to baseline scenario values, reaching 60.02 million GJ in the horizon year, which account for 5.5% of sectoral consumption, slightly higher than baseline scenario results.

As no hypotheses exist on new sources' penetration in this subsector, energy consumption will still rely exclusively on petroleum products.

Given performance improvements in interurban buses, diesel oil's share and its consumption decrease by 23% in 2020, compared to the baseline scenario. Consequently, jet fuel grows percentwise (58.1% in 2020).

Figure 49 Interurban passenger transportation. Consumption by source and mode
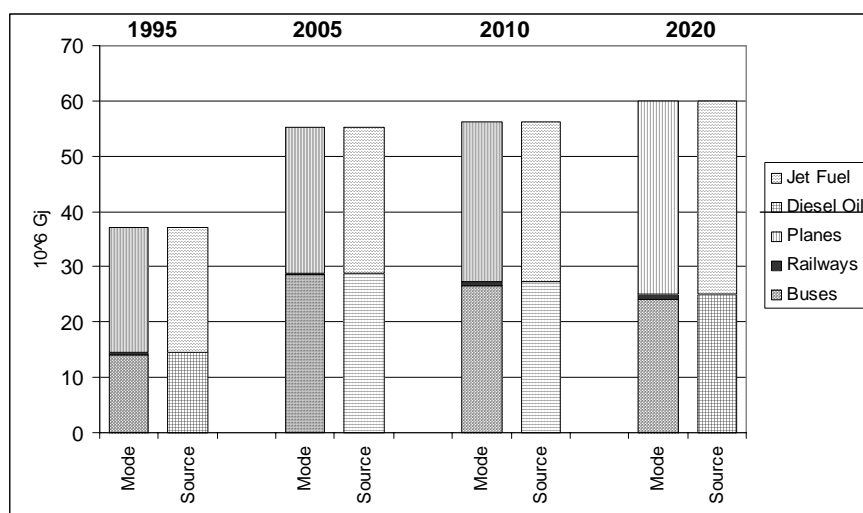
3.1.3 Freight transportation

Freight transportation accounts for a growing share of the sector's consumption, increasing to over 64% in 2020. The average growth rate amounts to 3.35% per annum for the whole period.

Total consumption in 2020 reaches 700.72 GJ, 15.1% lower than in the baseline scenario and 128% higher than in the base year. In spite of these movements, freight transportation will remain accounting for 81.5% of total diesel oil consumption for transportation.

Diesel oil will be the predominant fuel (68% of the subsector's energy consumption) while no major changes are expected in transportation mode shares. To be pointed out is CNG penetration —28.6% of total consumption in 2020—, and hydrogen higher share (2.4% in 2020). CNG penetration is highly relevant, including the incorporation of the first CNG fuelled railways.

Regarding the role of energy sources in each transportation mode, the increase in diesel oil's predominance should be pointed out, as well as that of fuel oil compared to the baseline scenario and electricity and hydrogen gains. However, the freight transportation shall rely on non-renewable energy sources (accounting for 97% of total consumption); petroleum products still prevail; and the penetration of natural gas allows for a greater diversification and involves a positive effect on the subsector's GHG specific emissions. The effect of such results on emissions shall be discussed in the specific section.

3.1.4 The effects of mitigation measures

As a result of the mitigation options identified and already described, a substantial difference appears in the sector's accrued energy consumption. The accrued "savings" resulting from higher efficiency reach 1476 million Gigajoules, a figure representing 1.35 fold 2020's projected consumption and, around threefold the base year consumption. The following figure clearly identifies each source's responsibility in total accrued savings.

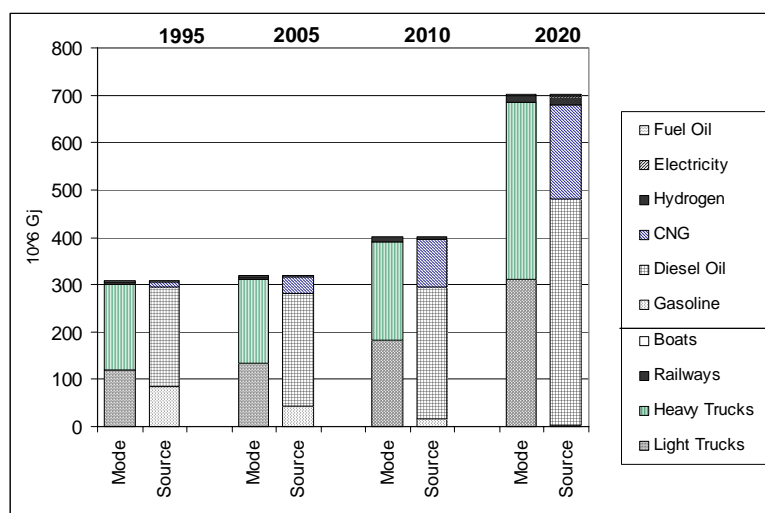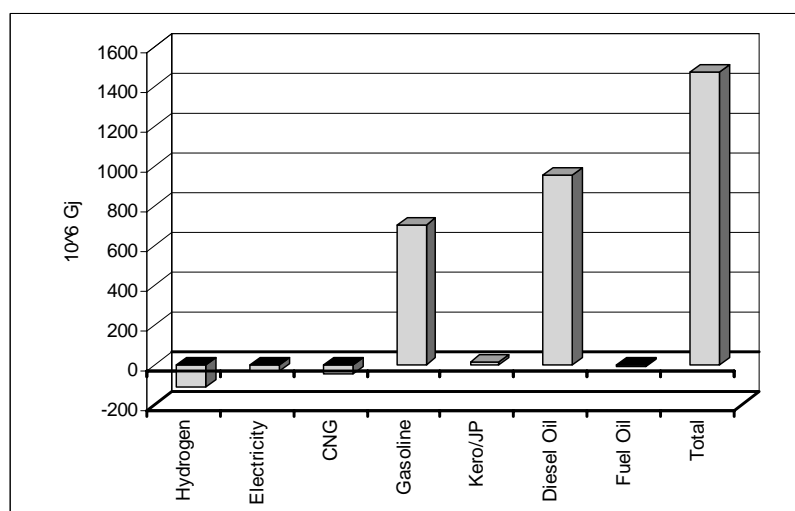*Figure 50   Freight transportation. Consumption by source and mode*

Figure 51   Accrued fuel savings

As seen in Figure 52, lower consumption is accounted for by diesel oil and gasoline (701 and 957 million Gigajoules respectively, for the 25 year period) and, to a lower extent, by kerosene/JP.

By reducing the consumption of highly emitting sources, a penetration of non-emitting energy sources, such as electricity and hydrogen, is achieved (at least at consumption level). Accrued difference in hydrogen consumption is 113 10^6 GJ and that of electricity 32 10^6 GJ.

The accrued additional consumption of compressed natural gas (CNG) accounts for 42 10^6 GJ and fuel oil for 8.61 10^6 GJ.

3.2   Industrial sector

Like in the baseline scenario, industrial energy consumption projections are aggregately presented for energy-intensive and non energy-intensive activities.

Figure 52   Annual difference in fuel consumption
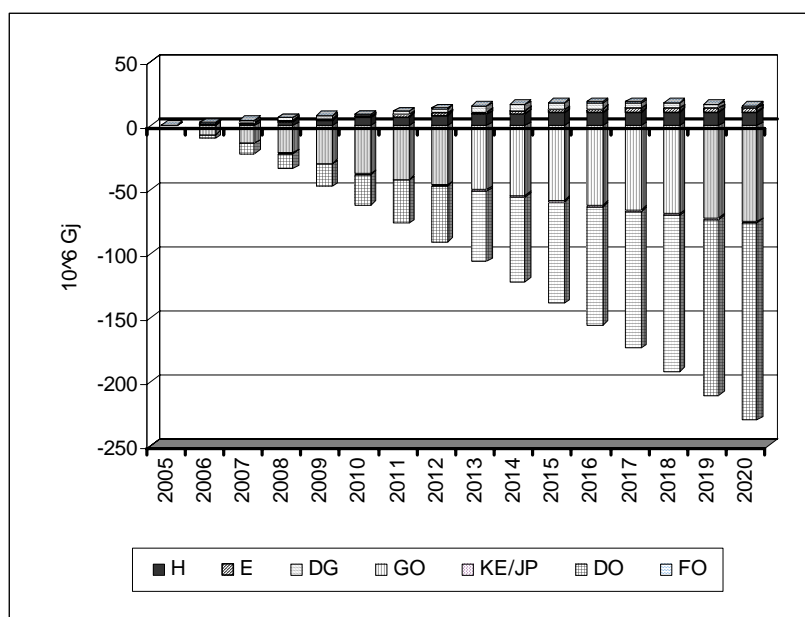
Energy-intensive activities used 269 million GJ in 1995 and will reach 561 GJ in 2020. Such consumption's evolution and the pertaining growth rates appear in Table 49:

Table 49   Energy consumption and growth rates for energy-intensive activities

	Unit	1990	1995	2005	2010	2020
Energy consumption	Mill GJ	215.86	268.88	344.04	410.57	561.08
Average annual rate	%		4.57	2.50	3.60	3.17

Two additional energy products appear in the mitigation scenario: electricity cogenerated burning natural gas and electricity cogenerated from biomass burning. The role of cogeneration as a mitigation option has already been explained in the previous section. However, for the sake of showing the results in Figure 53 electricity consumption is presented regardless of the source of power supply (public grid, self-generation or cogeneration)

The figure shows that biomass increases its share in the period under analysis (other primary sources) as well as distributed gas. Fuel oil, gas oil, petroleum coke and coke-oven and blast furnace gases plummet.

Non energy-intensive activities' results appear in the following table:

Table 50   Energy consumption and growth rates for non energy-intensive activities

	Unit	1990	1995	2005	2010	2020
Energy consumption	Mill GJ	142.47	191.18	236.57	267.00	369.07
Average annual rate	%		5.97	2.15	2.43	3.29

Biomass penetration (other primary sources) and distributed gas prevail in this subsector. Fuel oil evidences a backward trend, as does diesel oil to a lesser extent.

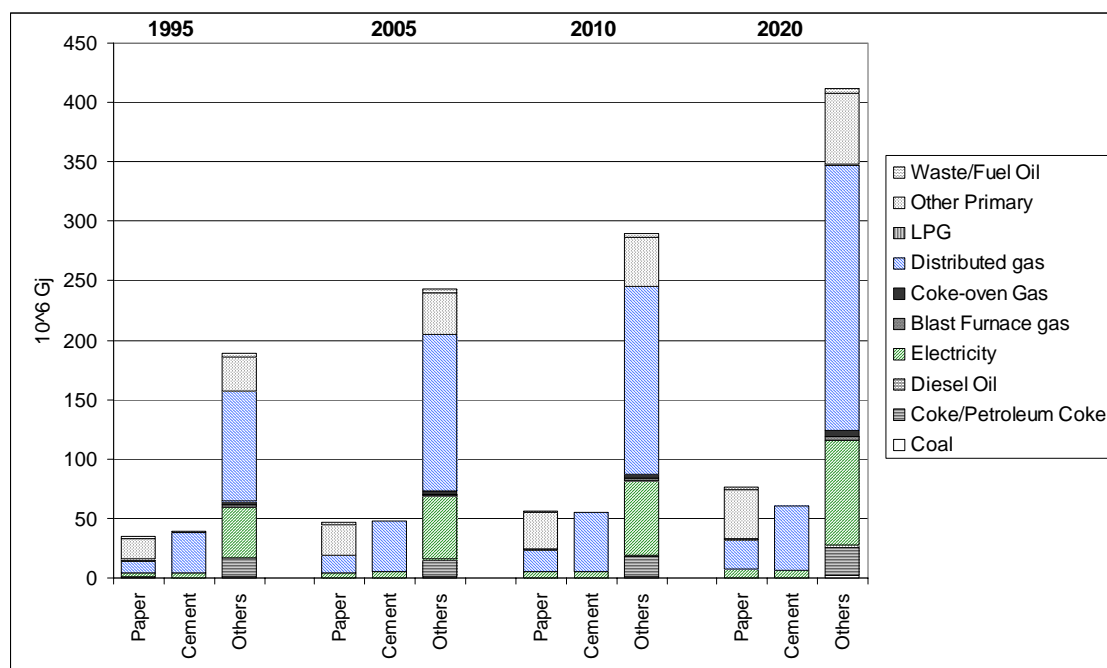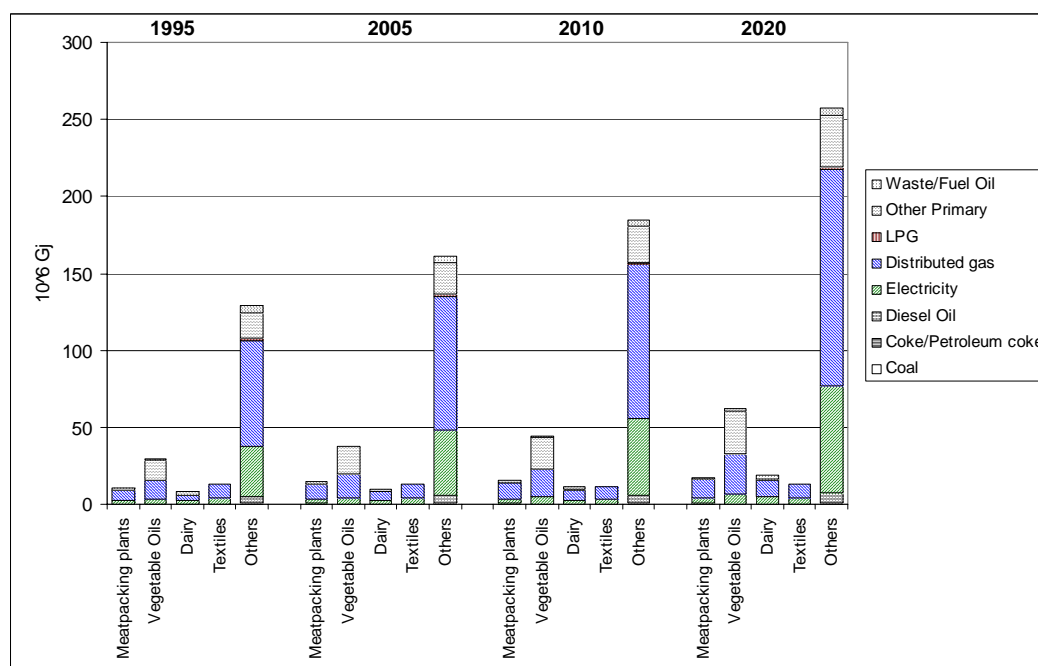*Figure 53   Energy-intensive activities. Consumption by branch and source*

*Figure 54   Non energy-intensive activities. Consumption by branch and source.*

3.2.1 The effects of mitigation measures

The assumed hypotheses on possible mitigation actions in the industrial sector by enhancing existing equipments' efficiency, substituting energy sources, new technologies and more efficient processes generate a spectacular impact. All the sources considered, without exception, evidence positive accrued savings, so that total accrued savings amount to 2715 million GJ, almost threefold the sector's total consumption in the horizon year (930 million GJ).

In 2020 the difference between both scenarios amounts to 24.7%. Of such savings, distributed gas accounts for 55% and electricity for 20%. The energy intensive industry decreases its consumption 21.2% while the non energy-intensive does by 29.5%, in both cases compared to baseline scenario values. Effects can be noted in the following figure, which clearly shows that lower consumption is accounted for by distributed gas, electricity and other primary sources.

Figure 55   Accrued savings by source
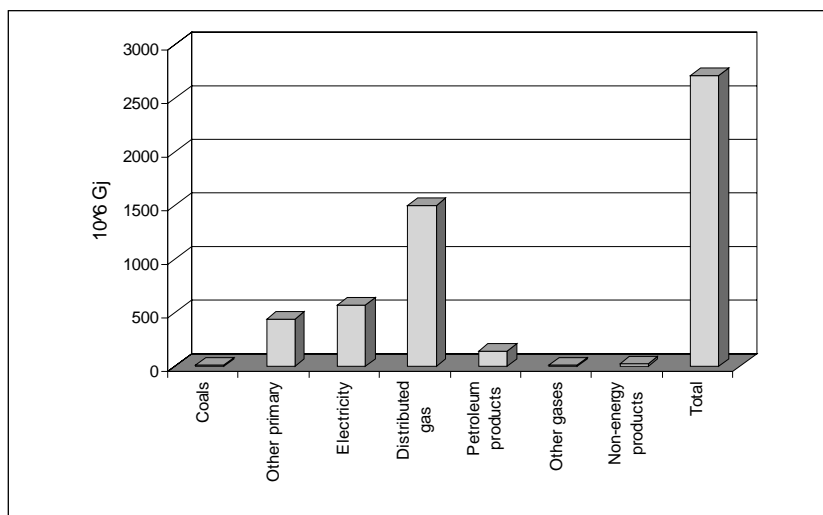
3.3   Self-consumption

As energy consumption from the energy supplying industries (self-consumption) depend on their activity level, which in turn result from final and intermediate energy consumption from the economic sectors, it is only natural for values between both scenarios to differ.

Table 51 includes consumption by source for milestone years.

Table 51   Self-consumption

Source	1995	2005	2010	2020
Coal	1.01	1.03	1.44	2.51
Electricity	1.55	2.38	2.94	4.20
Distributed gas	126.63	152.97	184.41	258.30
Refinery gas	21.27	35.91	43.23	57.88
Diesel oil	4.90	4.98	5.94	10.52
Fuel oil	22.65	13.71	15.05	23.07
Petroleum coke	4.23	3.32	3.96	6.48
Non-energy product	0.25	0.83	0.79	1.21
TOTAL	182.47	215.13	257.77	364.17

Differences between the horizon year and the baseline scenario amount to 65.93 GJ, i.e. 15.3%. Ninety five percent of such "savings" originate in distributed gas (62.4 10^6 GJ).

3.4   Aggregate results

The mitigation and baseline scenarios total energy consumption differs as a result of mitigation actions assumed in the above-described sectors. The resulting final demand explains such differences by source and total consumption as illustrated in Table 52.

Table 52   Total final consumption

Source	1995		2005		2010		2020	
	Mill GJ	%	Mill GJ	%	Mill GJ	%	Mill GJ	%
Hydrogen					6.19	0.2	27.07	0.7
Biomass & Other Primary	94.05	5.2	121.41	5.2	143.59	5.1	197.64	4.9
Coals	3.58	0.2	4.15	0.2	5.1	0.2	7.69	0.2
Petroleum products	700.90	38.9	802.47	34.2	908.80	32.0	1229.76	30.4
Electricity	200.92	11.1	311.86	13.3	392.87	13.8	575.58	14.2
Distributed gas	660.75	36.7	919.27	39.2	1159.09	40.8	1693.56	41.9
LPG	59.24	3.3	68.96	2.9	75.58	2.7	91.15	2.3
Other gases	26.77	1.5	40.41	1.7	48.61	1.7	65.52	1.6
Non-energy products	56.52	3.1	78.00	3.3	98.83	3.5	155.60	3.8
TOTAL	1802.73	100.0	2346.53	100.0	2838.66	100.0	4043.57	100.0

Changes with respect to the baseline scenario are summarised in the following remarks:

- The average annual growth rate between ends (1995/2020) amounts to 3.3% (0.5 % below the baseline scenario).

- Average annual rates by periods read as follows

1995/2005	2005/2010	2010/2020
2.7%	3.9%	3.6%

- Energy productivity, measured on final consumption (GDP/Final Consumption) evolves to the following values (in 1994 dollars per Gigajoules):

| 1995	2005	2010	2020
149.3	170.9	180.1	195.2

- Productivity improves by 2.7% in 2005, 6.9% in 2010 and 14.5% in 2020, always with respect to baseline scenario values.

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

Scenario	2005	2010	2020
Baseline	+34%	+68%	+157%
Mitigation	+30%	+57%	+124%

As for analysis by energy source, the following aspects should be highlighted:

- Distributed gas' share increases (0.3% above the baseline scenario), petroleum products lose share (1.5%) and electricity lowers its share (0.5%).

- As expected, the final consumption structure implied "less emission" than in the baseline scenario.

Figure 56   Final consumption by source
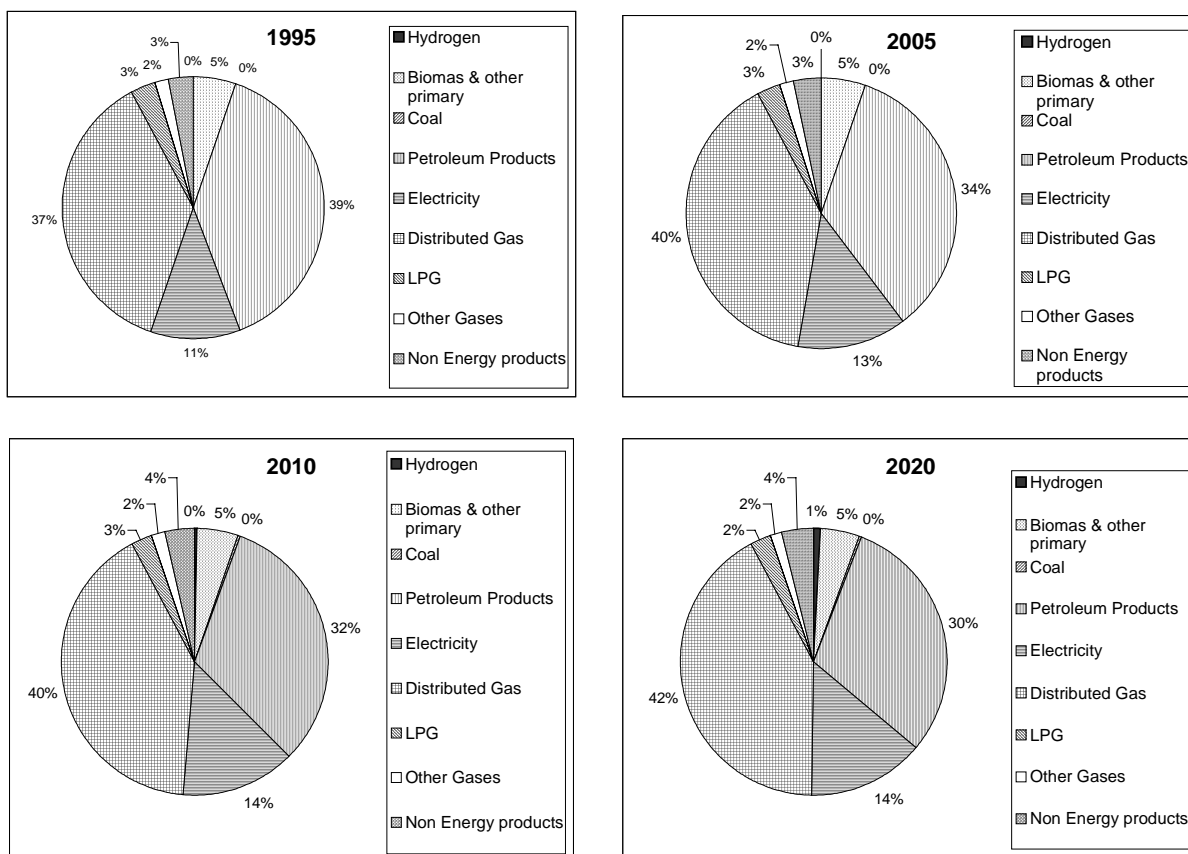
As mitigation actions have only been considered for transportation and industry, such sectors lose share in total energy consumption. It seems no necessary to analyse in detail these movements as the remainder sectors exhibits no changes with respect to baseline scenario assumptions.

4 Energy supply in the mitigation scenario

The characteristics of energy supply in the country —should mitigation actions described in Section 2 above be implemented both in end-use sectors and in energy supply-related activities— are presented herein. In order to facilitate the understanding of results, permanent reference shall be made to changes with respect to the baseline scenario when analysing the evolution expected in each of the energy industries.

4.1 The electricity industry

Should mitigation options considered for end-use sectors (transport and industry) be implemented, in the horizon year final electricity consumption would be almost 10% lower than in the baseline scenario. This means that domestic electricity consumption would grow at 4.6% average annual rate until the year 2010 and at a slightly lower rate —4% a year— from then on. Just like in the baseline scenario and to estimate local generation future needs, such domestic consumption was added the expected inter-country electricity trade, whose results appear in Table 53.

Table 53   Electricity requirements

		1995	2005	2010	2020
Final consumption	PJ	200.92	311.70	392.87	575.57
Annual rate	Subperiod (%)		4.5	4.7	3.9
	Accrued (%)		4.5	4.6	4.3
Imports		8.43	34.54	68.61	68.61
Exports	PJ	0.81	28.35	45.12	75.12
Net Balance		-7.62	-6.19	-23.49	6.52
Total requirement		193.30	305.51	369.38	582.09
Annual rate	Subperiod (%)		4.7	3.9	4.7
	Accrued (%)		4.7	4.4	4.5

In this case as well, the electricity imports described in the table account for the binational hydropower plants' portion (shared with Paraguay) geared to the Argentine market exceeding the 50% corresponding to Argentina. Therefore, in terms of electricity supply technology imports can be considered as hydroelectric generation.

Exports, in turn, should be interpreted as exports net from contingent imports and resemble those assumed in the baseline scenario. As noted, only by the end of the period under analysis exports shall increase the need to expand local supply above local requirements. In any way, in the horizon year total electricity requirements from domestic power stations shall be 14% lower than in the baseline scenario. Until 2010, imports from binational power stations shall exceed foreseen exports.

Electricity self-production's share to meet such requirements shall resemble that of the baseline scenario (about 6%), only over 50% would originate in cogeneration in the industrial sector as a result of the hypotheses considered when estimating such sector's energy consumption, described in Section 2 above.

Electricity self-production's retrofitting into cogeneration would involve savings between 25 and 30% in energy consumption versus the values expected in the baseline scenario. Additionally, fossil fuels would lose share to a higher use of biomass wastes. In spite of this, natural gas would still hold a share close to 68% in the total used in such power stations.

To estimate electricity generated by the utilities' power plants the percentage of transmission and distribution losses remained as in the baseline scenario (11%). Such constant total losses, in a supply structure with a higher hydroelectric generation share involve additional efforts by distributors to reduce distribution losses to under 9%, as high voltage transmission losses in the mitigation scenario are expected to be higher than those estimated in the baseline scenario.

Following a criterion similar to that applied in the baseline scenario, it was assumed that the strongest effort to decrease distribution losses shall be made in coming years,

as distributors' economic interest is at stake. Consequently, while electricity requirements would increase by 61% between 1995 and 2005, electricity generation should only increase 49% in the same period.

Even if electricity generation will grow less than in the baseline scenario, the incorporation of new power stations in the coming years was kept at the same rhythm. The fact is that most of these new stations are already under construction and the remaining ones are required by operators to improve their market competitiveness.

Therefore, also in this case it is considered that 8100 MW shall be incorporated until the year 2005 to 1995's installed capacity, including 5700 MW in fossil fuelled plants, 1700 MW in hydropower stations and 700 MW resulting from the start-up of the third nuclear power plant. Thus, the reserve percentages would be even higher than in the baseline scenario, amounting to about 60% of the system's peak load in the year 2005.

For the long-term it was considered that the dynamic of supply expansion would adjust to the electricity demand evolution, both because of caution on the part of investors and the fact that the power stations incorporated are capital intensive.

This fact, together with domestic electricity demand's slower growth rate, would permit to install around 5000 MW less than in the baseline scenario throughout the 2005-2020 period, even assuming the shutting down of 1700 MW in obsolete groups. In terms of power added "in the country", savings could reach 6400 MW, as 1400 MW of imports have been included from a new power station shared with Paraguay. Anyway, the underlying assumption is that such station would be defined on the basis of its insertion in the Argentine market, and therefore imports are an artifice to highlight its binational nature.

The search for GHG emission-free generation technologies involves not only savings in installed capacity but also a radical change in the mix of incorporated power stations. To meet the system's requirements the following were incorporated in the 2005-2020 period

1. about 7000 MW in hydropower stations
2. 2100 MW in nuclear power plants
3. 4200 MW in high efficiency combined cycles
4. 70 MW in wind generators in isolated areas, and
5. 1500 MW in gas turbine stations to meet peak demand

As seen in Figure 57, such strategy to diversify electricity generation technologies results in keeping almost constant the present technology mix of electricity generation. Differing from expectations in the baseline scenario, the contribution of fossil-fuelled plants would not exceed 50% of the generation from public service power stations, although combined cycles would still contribute over 80% of fossil-fuelled stations' total generation in the year 2020.

Considering that electricity imports would originate in binational hydropower stations, hydro contribution would grow 6% compared to the figures appearing in Figure 57, accounting for almost 45% in the year 2020.

Both scenarios also differ in the amount and type of energy sources used in power stations. As regards structure and as seen in Figure 58, fossil fuels shall gradually lose

194

share to reach 54% of total power stations' inputs in 2020, compared to 82% expected in the baseline scenario.

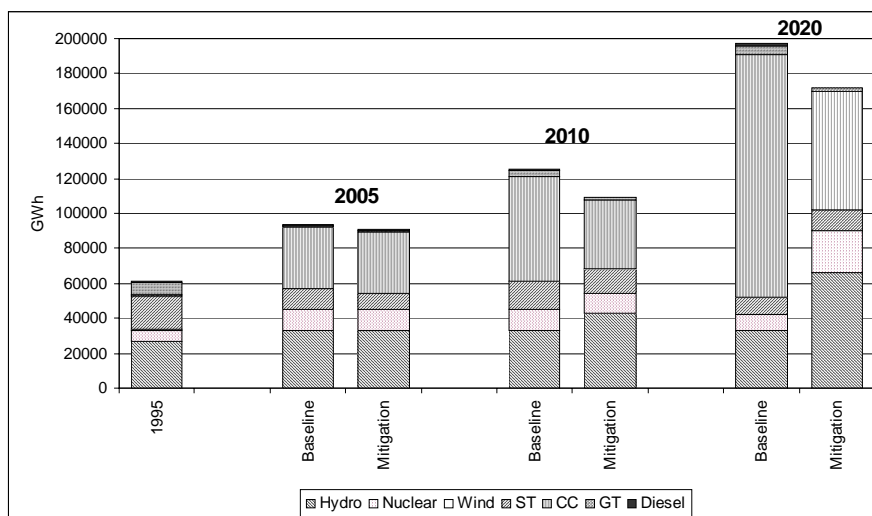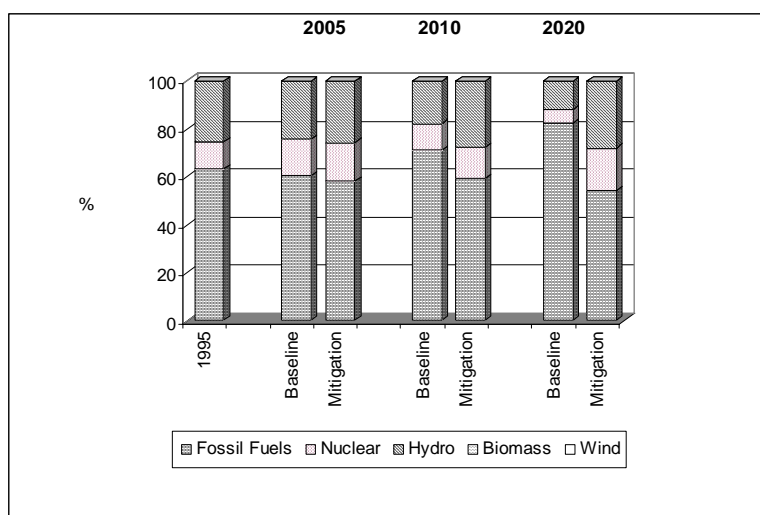*Figure 57   Generation by generating technology*


Figure 58   Generation by fuel

Among fossil fuels, natural gas will also have an increasingly relevant role, accounting for 91% of the total fossil fuels burnt by public service power stations in 2020, as illustrated in Figure 59. However, the volume of natural gas burnt by power stations would be 46% lower than the estimation made for the baseline scenario. Consequently, lower gas demand, expected to grow at 3% per annum the next 25 years, would pose less pressure on the gas industry, as discussed in the next section.

Figure 59   Fossil fuels burnt in power stations
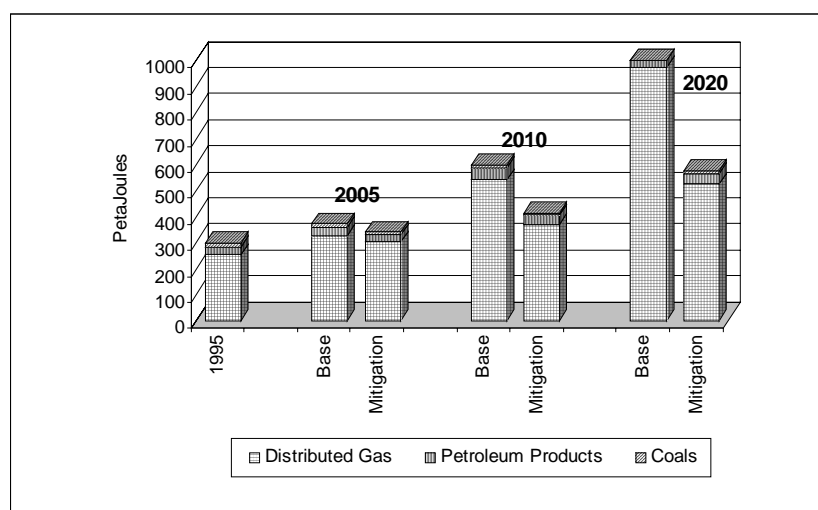
However, such growth in gas demand from power stations shall be uneven throughout the period, i.e. until 2005 the incorporation of hydro and nuclear power stations presently under construction will attenuate the increase in generation from fossil-fuelled power plants. On the other hand, as of 2005 power stations' gas demand is expected to grow at 3.8% annually until the horizon year, which in any case accounts for only 50% of the rates expected for the baseline scenario. Petroleum products' substitution would be even faster than in the baseline scenario and less conditioned by the gas industry evolution. Power stations are expected to burn very few liquid fuels (about 7% of the fossil fuels' total).

Like in the baseline scenario, the incorporation of advanced-technology combined cycles will allow for an increase in fossil-fuelled plants' average performance from 33% in 1995 to 51% in 2020. Had such remarkable growth in thermal efficiency not been assumed, fossil fuels consumption would have been 55% higher than expected.

4.2   The gas industry

According to the projections made —whose results appear in Table 54— in the next 25 years the domestic demand of gas would grow in the mitigation scenario at a noticeably lower pace than in the baseline scenario, 3.6% annually versus 5%.

Table 54   Natural gas demand in the mitigation scenario

|		1995	2005	2010	2020
Residential/comm.		253.13	351.70	417.67	571.41
Industrial		245.99	328.60	385.86	527.36
Transportation	PJ	35.01	86.00	171.15	336.49
Power stations		284.41	327.66	399.02	566.35
Total domestic demand		818.54	1093.96	1373.70	1998.61
Annual rate	Subperiod (%)		2.9	4.7	3.8
	Accrued (%)		2.9	3.5	3.6
Foreign trade balance	PJ	-73.79	234.40	361.15	277.81

This table also attempts at illustrating the customers categories normally used by gas distributors. Thus, industrial values include all the natural gas used for both energy

196

and non-energy purposes in the industry. On the contrary, power stations consumption includes, besides the gas burnt in public service power stations, the gas used for self-production and cogeneration, which are normally considered as industrial consumption by distributors.

It was assumed that in the mitigation scenario the natural gas foreign trade conditions would be similar to that expected in the baseline scenario. In this case, the impact of natural gas exports on total requirements would be higher than that expected in the baseline scenario, due to the slower growth pace of domestic gas demand. In 2010 exports would account for 25% of domestic consumption, although such relevance would gradually decrease to 14% in the horizon year due to domestic demand growth and the expiration of the first export contracts which are assumed as non-renewable. Considering total requirements, both domestic and foreign, demand would grow at a 5.8% average annual rate until the year 2010, i.e. one percentage point below the baseline values.

Differently than in the baseline scenario, a certain stability is expected in the sectoral structure of natural gas' domestic demand, with the exception of CNG growth for transportation, which would account for almost 17% of the domestic gas market, vis-à-vis a meagre 4% in the base year. Such results can be seen in Figure 60, where structural changes expected in the baseline scenario are also illustrated.

Figure 60   Sectoral structure of natural gas' domestic demand
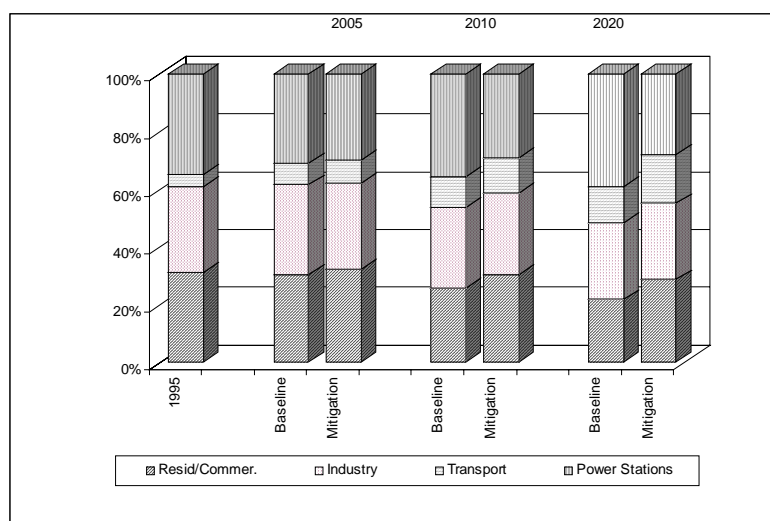
The consequences of each electricity supply strategy on the natural gas domestic market shall only be evident as of 2010, becoming stronger towards the end of the period. A diversify power generation mix would decrease electricity power stations' share by over 6 points compared to the base year and 11 points compared to the baseline scenario.

On the basis of expected gas requirements, the evolution of natural gas gross domestic production was also estimated, considering:

1. transportation and distribution losses,
2. gas industry own consumption,

3. liquid hydrocarbons extraction from natural gas, and

4. gas vented in gas fields.

No substantial changes are expected in any of these processes with respect to the baseline scenario. From GHG emissions' standpoint, the most relevant are gas venting in gas fields, leaks in the transportation and distribution systems and own consumption for compression in the transportation system.

As for gas venting, it seems very difficult to reduce it below the amounts already defined by the energy authorities, which as seen implies decreasing such venting to 2% of net production from re-injection, compared to close to 10% in the base year. In losses and own consumption, a slight improvement was assumed with respect to the situation recorded in 1995.

Therefore, the differences in the evolution of natural gas domestic production between both scenarios (seen in Figure 61) only reflect different growth pace of domestic consumption. Although, in the mitigation scenario too the annual growth rate of natural gas production would be almost one percentage point below the expected growth rate for total gas requirements.

The hypothesis made in the baseline scenario on the oil companies' policy to expand natural gas reserves in the country was maintained, thus assuming that an intensive and successful exploration will allow to incorporate 70,000 million cubic meter of new gas reserves per year. However, varying gas production rates, especially after the year 2005, would imply substantial changes in the remaining natural gas reserves in the horizon year, as evidenced in Figure 62.

Figure 61   Natural gas domestic production
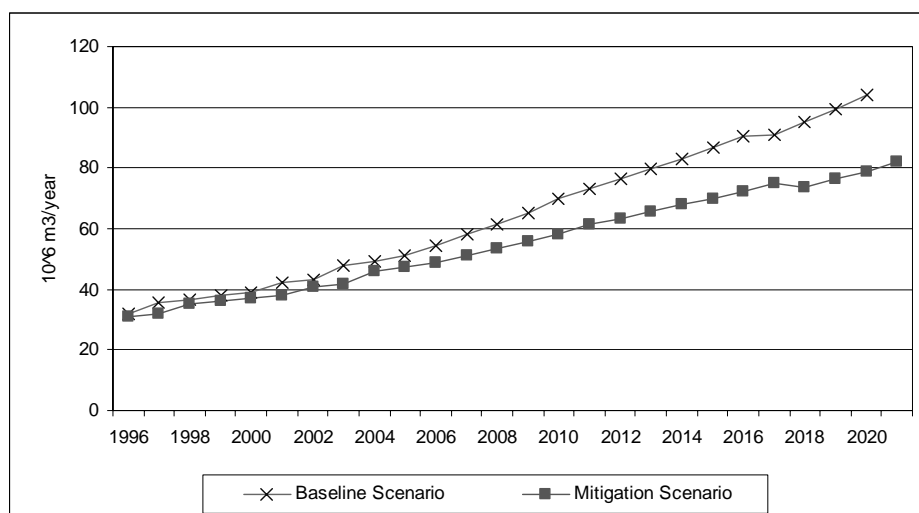
After reaching a maximum value close to one trillion cubic meters in the year 2010, the remaining natural gas reserves in the mitigation scenario would practically remain stable around that figure up to the year 2020, preventing the 20% drop in the reserves observed in the baseline scenario.

198

Figure 62   Remaining natural gas reserves
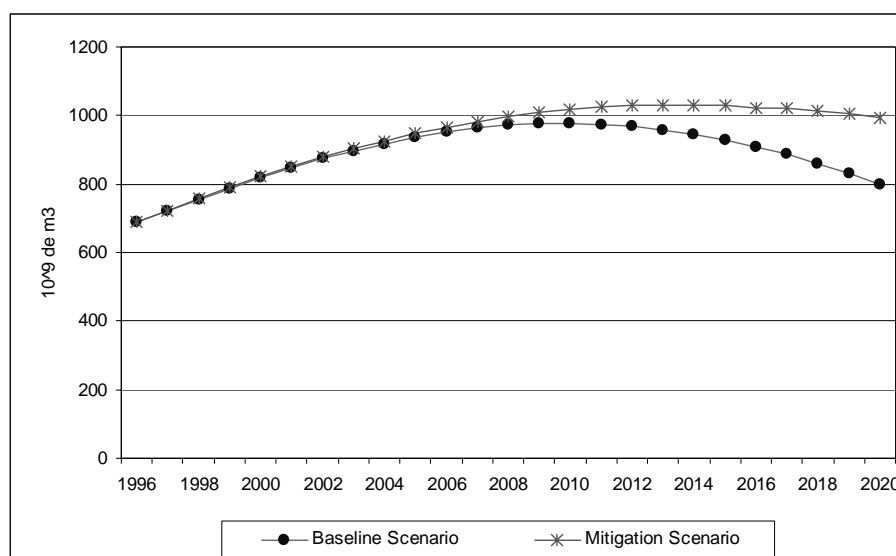
This stabilisation of remaining gas reserves, however, would not prevent the
reserves/production ratio to drop systematically also in the mitigation scenario as of
2005, although the drop will be less steep than in the baseline scenario, as seen in
Figure 63.

Figure 63   Natural gas reserves/production ratio
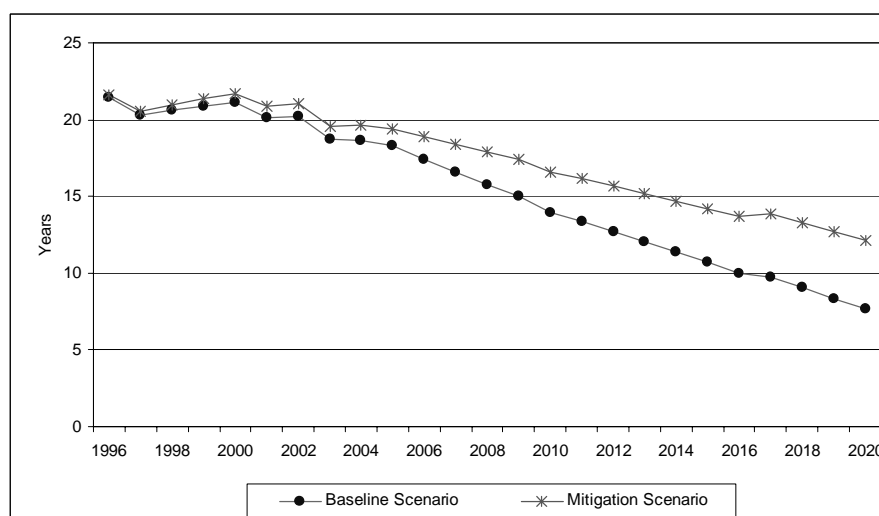
In this case, the remaining reserves in the horizon year would still exceed the ten-year
horizon that the Energy Secretariat considers the minimum prerequisite in its 1997
Prospective Study. Gas field operators could have two alternative reactions to such
situation: increase their foreign sales or decrease the efforts to find new gas reserves.

Under the first strategy, production could increase by 18% in the horizon year without
affecting the limit established on the 10-year reserves/production ratio, allowing to
double that year expected exports in the mitigation scenario.

Exploration efforts could decrease as long as the incorporation of 1500 billion cubic
meter reserves until the year 2020 is ensured. This means guaranteeing, in average, the

discovery of 63,000 m3 a year. Although such values are 10% lower than those assumed in the baseline scenario, they are anyhow 25% higher than those recorded in late years. On the other hand, this lower pressure on the gas industry would not substantially enhance the probability of having as much gas resources in the country as needed to sustain such an energy strategy. In this case, Argentina's ultimate natural gas resources should be at least 2.3 trillion cubic meters, i.e. only 7% less than is required to render the baseline scenario viable.

4.3   The oil industry

Table 55 illustrates the country's expected evolution of petroleum products' total consumption in the mitigation scenario, including both the consumption expected in end-use sectors and its use in transformation centres, regardless of the fact that the use they are meant for is energy-related. The table also includes each subperiod's average annual growth rates as well as those corresponding to the period accrued since the base year.

Just like in the baseline scenario, petroleum products were grouped as follows: light products (LPG, kerosene, gasoline, and refinery gas); intermediate products (diesel oil); heavy products (fuel oil and petroleum coke); and non-energy products.

Table 55   Petroleum products consumption

		1995	2005	2010	2020
Light products	PJ	353.0	337.8	315.6	311.3
Intermediate products		382.1	522.9	643.3	970.7
Heavy products		89.5	60.1	71.2	94.5
Non-energy products		56.5	78.0	98.8	155.6
Total Consumption		881.1	998.7	1128.9	1532.1
Annual rate	Subperiod (%)		1.3	2.5	3.1
	Accrued (%)		1.3	1.7	2.2

As a result of the mitigation actions considered, petroleum products' consumption is expected to grow at a 2.2% average annual rate in the next 25 years, accounting for horizon year values 16% lower than those expected in the baseline scenario.

In this case too, the expansion rate of petroleum products' consumption in the country would not be even throughout the whole period, growing from a modest 1.3% in the next ten years to 3.1% between 2010 and 2020. In spite of the efforts made in the industry and transportation, and the stabilisation of petroleum products' burnt in power stations, the strong expansion of non-energy consumption and the use of gas oil in agriculture prevents petroleum products' domestic consumption from further decreasing.

Varying consumption sectors dynamics shall result in changes in the petroleum products sectoral consumption, as illustrated in Figure 64 where baseline scenario values have also been included in order to visualise changes originating in the mitigation actions implemented.

Mitigation actions implemented in the transport sector would reduce its share in total petroleum products consumption to 47% in the horizon year, compared to 52% in the baseline scenario and 55% presently. It should be noted that some 18% of petroleum products used in the horizon year would have non-energy purposes, i.e. GHG

emissions would be prevented. The agriculture and cattle breeding sector could be the focus of future mitigation actions, as the expected expansion in primary production would place such sector second in petroleum products domestic consumption (22%).

Figure 64   Petroleum products consumption by sector
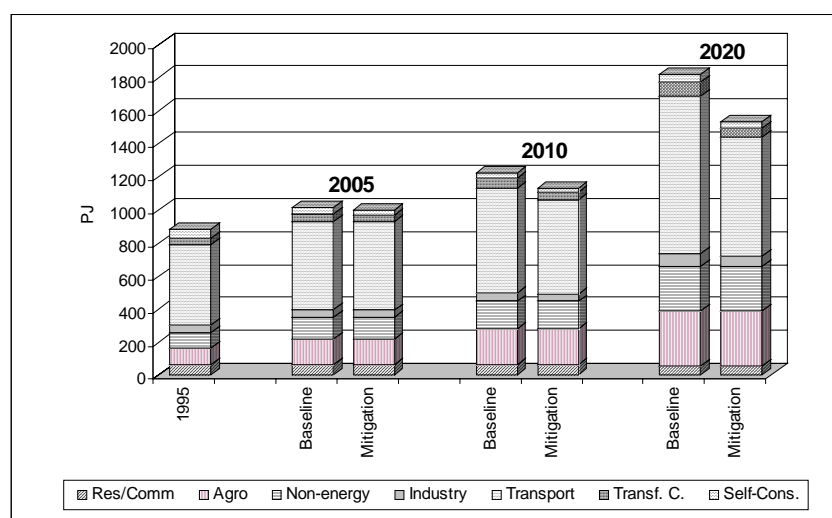
Such changes would result in significant movements in the type of petroleum products required throughout the period, just like in the baseline scenario. In this case, light petroleum products consumption would decrease by 12% with respect to the base year, while diesel oil demand would expand at a 3.8% average annual rate along the next 25 years, reaching 63% of the country's total petroleum products consumption.

Although such values differ from the baseline scenario, the share of each type of petroleum product in total consumption will follow a similar trend in both scenarios. Consequently, the same type of adaptation in refineries' production structure would be required, i.e. also in this case catalytic hydrocracking plants would have to be installed in order to increase diesel oil production through fuel oil conversion.

In spite of the fact that total petroleum products consumption in the horizon year would be 16% lower than in the baseline scenario, to meet such demand after the year 2010, it will be necessary to increase crude oil processing capacity in domestic refineries. Additional capacity would amount to 43,000 m3/day until the horizon year.

Based on such changes, each type of petroleum products' domestic production was estimated, whose evolution is illustrated in Figure 65 where light petroleum products contribution (LPG and gasoline) from gas separation centres is identified. Although the expected gas production expansion would also lessen refineries' share in light petroleum products' total production (77% in the horizon years), such changes would be lower than those expected in the baseline scenario (73%).

As seen in the figure, differences between both scenarios in petroleum products' domestic production would be less important than in consumption. This is mainly due to the fact that in the mitigation scenario diesel oil's expected demand would be met with local production whereas in the baseline scenario 13% would be imported.

In spite of such changes in the refining structure, light and heavy petroleum products exportable surpluses are expected throughout the period, higher than those foreseen in the baseline scenario. In the case of light petroleum products, exportable surpluses

would systematically grow from 18% of the domestic production in the base year to 52% in the year 2020. The share of gasoline in these exportable surpluses would grow to about 81% in the horizon year. A similar evolution would affect heavy petroleum products exportable surpluses, basically fuel oil, accounting for about 68% of the domestic production in the year 2020.

Figure 65   Petroleum products production
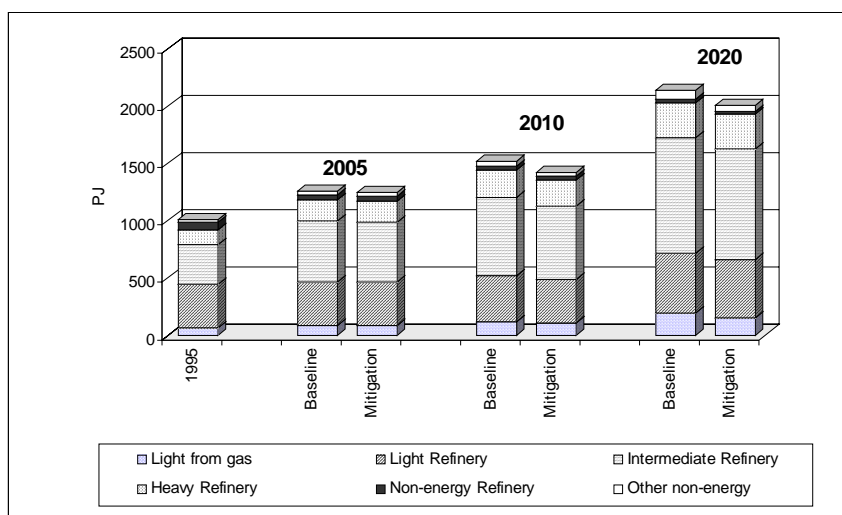
Such crude processing estimates in domestic refineries were confronted with crude oil local production figures resulting from production companies' strategy, within the limits imposed by the country's oil reserves.

It was assumed that the implementation of mitigation actions within the national territory would not substantially affect national oil companies' strategy, particularly as regards investments within and outside the country. Consequently, oil production and the incorporation of new reserves remained equal to those considered in the baseline scenario.

It is true that an international context characterised by growing concern to mitigate climate change could alter the quality of the oil business from the oil companies standpoint. However, it is estimated that the price/cost ratio in such industry would still allow for high activity levels even in a more unfavourable market context, although it would affect the industries' profits.

On the other hand, baseline scenario assumptions about explorations to search for new oil deposits in the country were not excessively optimistic. In any way, changes in the behaviour of national oil companies compared to the present assumption would only increase the reliance on imports for domestic supply, in a market characterised by large supply and low prices.

As such hypotheses shall not substantially affect GHG emissions, and considering that the issue is beyond the scope of the present project, it was not deemed necessary to analyse alternatives for oil companies' assumed behaviour.

Figure 66 illustrates the changes expected in crude oil sources and destinations in the country during the period under analysis, as a consequence of operators' expected behaviours. As noted, in spite of refineries' crude oil demand drop, 30% of the

domestic supply would rely on crude oil imports in the horizon year, compared to 34% in the baseline scenario.

Figure 66   Crude oil sources and destinations
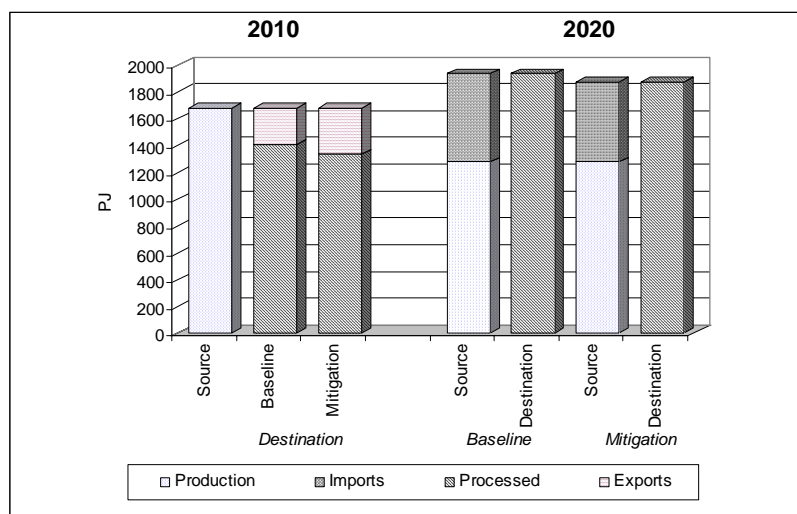
4.4   Primary energy consumption

Under mitigation scenario conditions, primary energy consumption growth along the next 25 years would amount to 2.9% annually, with a faster pace after the year 2005 (3.5% annual), in line with the trends described when analysing final energy consumption.

The mitigation actions implemented, especially in the electricity sector, imply greater diversification in energy primary sources' consumption than in the baseline scenario, as noted in Figure 67.

Figure 67   Primary energy consumption
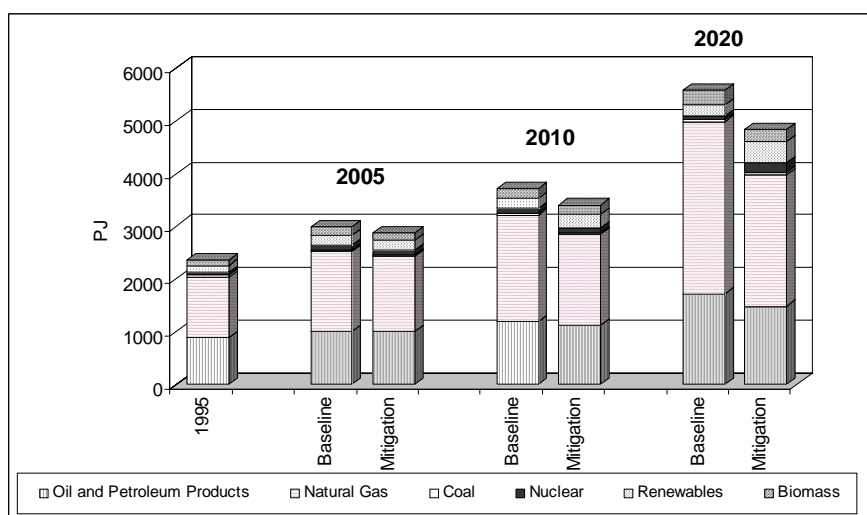
In this case, the oil and petroleum products share decrease (7% in the next 25 years just like in the baseline scenario) would be captured at the same pace by natural gas and renewable sources (3% each) and, to a lower extent, by nuclear fuel (1%). Although

203

renewable sources include both hydroelectricity and wind and hydrogen, the most substantial impact in terms of primary energy consumption would result from the construction of hydropower stations.

In any way, natural gas would still be the major primary source in Argentina, with 52% maximum penetration in the horizon year. If mitigation actions were applied, the present fossil fuels' share in primary sources consumption could decrease by almost four percentage points until the horizon year, reversing the upward trend expected in the baseline scenario.

As seen in Figure 68, the trend to improve energy supply efficiency would be enhanced in the mitigation scenario, understanding as such the ratio between final energy consumption in the country and the corresponding primary sources consumption to supply such needs. In order to facilitate the comparison of results, the figure exhibits evolutions expected in both scenarios.

Figure 68   Energy supply efficiency
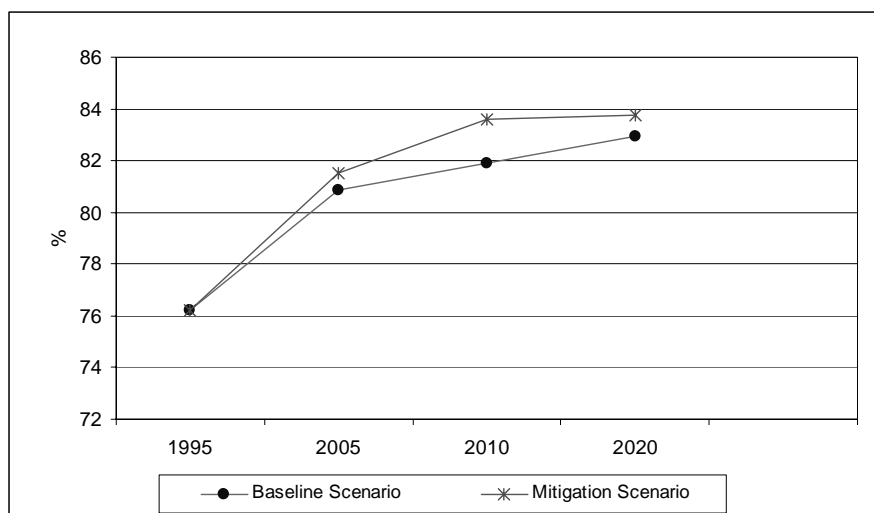
In the next ten years the supply system's evolution shall be highly conditioned by decisions already made by energy companies, and as mentioned when commenting baseline scenario results, the trend aims at efficiency's rapid growth.

Only in the 2005/2010 period significant differences are noted as regards supply efficiency between both scenarios. Electricity generation accounts for the major difference due to the incorporation of hydropower stations with 80% performance, compared to 55% performance in combined cycles.

The electricity sector is also responsible for the convergence of both curves in the last decade under analysis, as the higher hydropower efficiency is offset by the relative lower performance of the new nuclear power stations in the mitigation scenario.

The impact of mitigation actions on energy intensity is clearly seen when comparing the evolution expected in both scenarios, illustrated in Figure 69. Primary energy consumption per GDP unit would decrease some 30% by the year 2020, compared to present values. This means a ten percentage point reduction above baseline scenario expectations.

Such energy intensity reduction in the mitigation scenario compared to the baseline would mainly originate in the efforts made by end-use sectors, as energy supply efficiency differences between both scenarios are minor.

Figure 69   Energy intensity and per capita consumption
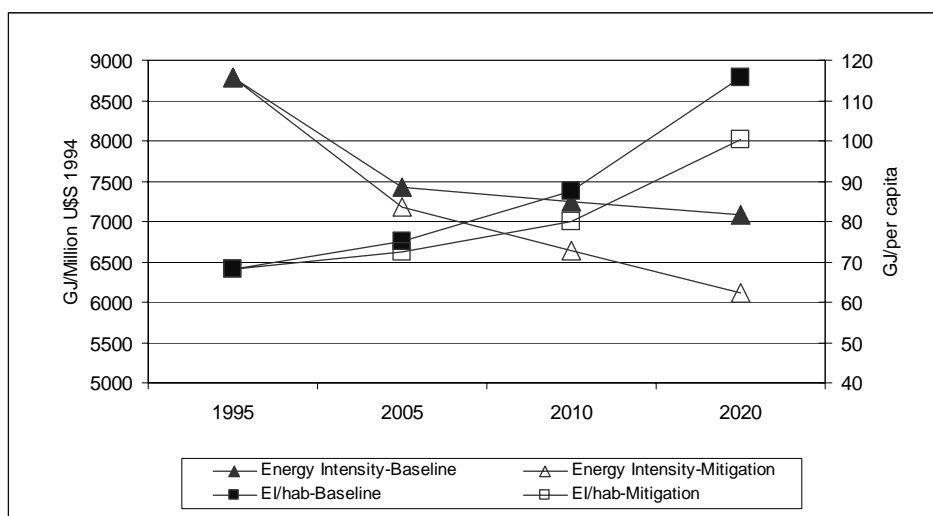
It is interesting to note that even when both scenarios render the same "energy service", the per capita primary energy consumption with mitigation actions would be about 14% lower than that expected in the baseline scenario for the year 2020. In any way, the rapid economic growth assumed, together with Argentina's low population growth rate would result in a clearly upward trend for per capita primary energy consumption in the country.

5   GHG emissions in the mitigation scenario

The expected evolution of emissions for the four considered gases in the mitigation scenario is illustrated in Table 56, where base year and 2020 baseline scenario values have also been included to facilitate the comparison between both scenarios.

Likewise for the baseline scenario, the table also includes the expected evolution of CO_2 volume equivalent to the four gases' joint emissions, considering the global warming potentials for each gas mentioned in Chapter VI, Section 4. As seen, the implementation of mitigation options would allow lessen the expected growth pace of CO_2-equivalent emissions from 3.5% per annum in the baseline scenario to only 2.6% per year. Such growth rate difference would imply almost 20% savings in CO_2-equivalent emissions compared to the baseline scenario's horizon year values.

Table 56 *GHG emissions in the mitigation scenario*

Gas type	Unit	Base year	Mitigation scenario 2005	Mitigation scenario 2010	Mitigation scenario 2020	Baseline scenario 2020
CO_2	Gg	118190	138440	161860	223780	281660
Annual rate	Subperiod (%)		1.6	3.2	3.3	
	Accrued (%)		1.6	2.1	2.6	3.5
CH_4	Gg	35.0	61.1	113.4	199.6	203.1
Annual rate	Subperiod (%)		5.7	13.2	5.8	
	Accrued (%)		5.7	8.2	7.2	7.3
NOx	Gg	684.1	824.1	1001.6	1463.4	1731.5
Annual rate	Subperiod (%)		1.9	4.0	3.9	
	Accrued (%)		1.9	2.6	3.1	3.8
CO	Gg	1752.9	1622.9	1538.9	1437.5	2052.0
Annual rate	Subperiod (%)		-0.8	-1.1	-0.7	
	Accrued (%)		-0.8	-0.9	-0.7	0.6
CO_2 equivalent	Gg	151671	177767	209319	291517	362052
Annual rate	Subperiod (%)		1.6	3.3	3.4	
	Accrued (%)		1.6	2.2	2.6	3.5

Although the considered mitigation options would have a stronger impact on CO_2 than on CH_4 emissions, direct CO_2 emission would account for about 77% of the horizon year total CO_2-equivalent emissions, i.e. a one percentage point drop with respect to baseline scenario expectations. Differences in the CH_4 share between both scenarios would not be very significant either.

The following sections discuss the expected evolution of each gas emissions, emphasising those of CO_2 due to its relative importance.

5.1 CO_2 emissions

5.1.1   *The evolution of total CO_2 emissions*

Even if mitigation actions will lessen total CO_2-emission growth in the next ten years as compared to the baseline scenario (1.6% annually vis-à-vis 2% in the baseline scenario), true differences between both scenarios are more clearly seen after the year 2005.

Figure 70 compares total CO_2 emissions' evolution in both scenarios as of the year 2010 and shows the sectoral structure.

As seen, total emission savings would amount to 20700 Gg of CO_2 in the year 2010 increasing to 58000 Gg in the horizon year. In terms of baseline scenario expected annual emission such savings would imply 11% reduction in the year 2010 and almost 21% in 2020.

As mitigation options have not been considered for all sectors and/or activities, the sectoral structure of emissions would substantially change, as seen in Figure 70. Lower emissions from power stations allows for the energy supply-related activities to account for only 27% of total CO_2 emission in the horizon year, as compared to an expected 33% in the baseline scenario and 36% today.

In end-use sectors, mitigation actions adopted for transportation would not prevent a 0.5% increase in its total emission share, in spite of being 19% lower than the expected emission in the baseline scenario. Industrial share in total CO_2 emissions would be only 1% less than in the baseline scenario, even when its emissions would decrease by 25% in the horizon year when mitigation measures were applied.

Figure 70   Total CO₂ emissions
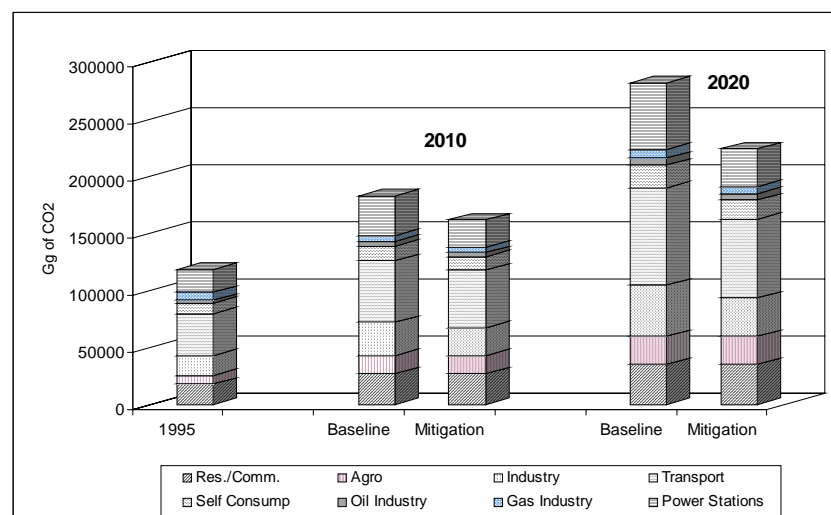
The share lost by energy supply-related activities in the mitigation scenario would be absorbed by the sectors where no mitigation actions have been assumed: agriculture and cattle raising and the residential, commercial and public sectors. Thus, their joint contribution to total CO_2 emission would go from the present 22% to 27% in the horizon year.

As previously stated, the sectoral structure can be misleading with respect to each sector and/or activity's true contribution to mitigate CO_2 emissions. In order to clarify such contributions, emission savings accrued throughout the period under analysis were calculated, and are shown in Figure 71 where the sectors and/or activities accounting for such savings are also mentioned.

It should be noted that the transportation, industry and power stations' lower energy consumption resulting from mitigation actions would decrease the activity level in other energy industries, and consequently their CO_2 emissions. The savings shown in Figure 71 represent total emission savings, including both direct impacts on the sector where mitigation measures are implemented and indirect impacts on energy supply.

As seen in the figure, the savings accrued in the next ten years would be unimportant because the baseline scenario already assumes a strong increase in energy efficiency, both in final consumption and in energy supply. After the year 2005, emissions' accrued savings would rapidly grow mainly driven by lower emissions from power stations.

However, it should be borne in mind that lower CO_2 emissions from power stations result from two causes. On one hand, higher hydroelectric generation will reduce conventional thermal production and, therefore, emissions from fossil fuels combustion in power plants. Additionally, the greater energy efficiency in end-use sectors will decrease electricity demand, indirectly reducing the amount of fuels burnt and increasing emissions' total savings in power plants.

Emissions saved from transportation could broadly exceed those from manufacturing industries (27% of total accrued savings compared to 19% until the year 2020), although such actions would be felt in the longer term.

Figure 71   Accrued savings in CO₂ emissions
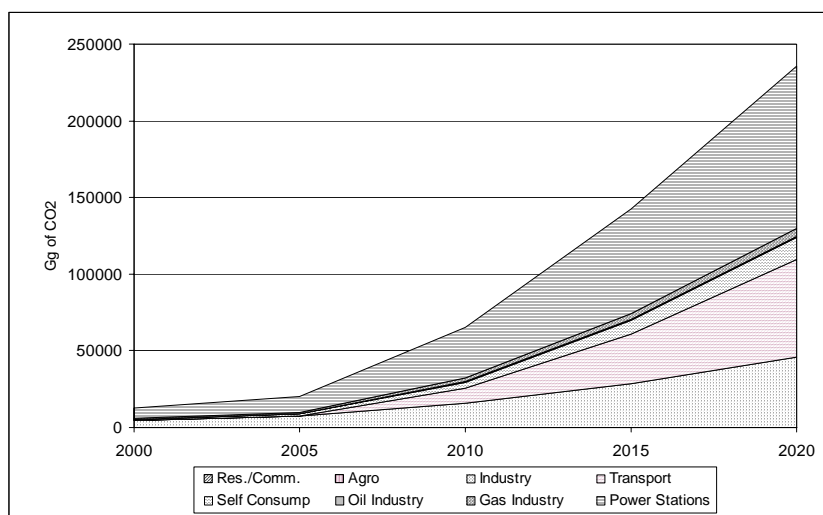
Finally, it should be mentioned that the gas industry contribution that appears in the figure only considers the decrease in natural gas losses and venting that would result from lower gas demand in the system. As pointed out when analysing the baseline expected emissions, the impact on emissions from the policy already implemented to reduce gas venting in fields is included in the evolution expected in the baseline scenario, although its nature of climate change mitigation measure is clear.

5.1.2   The evolution of CO₂ specific emissions

Following the criteria used to analyse the baseline scenario, the specific emissions from the whole energy system were calculated, as well as those from end-use sectors and energy supply, whose results appear in Figure 72. Said figure also illustrates baseline scenario values in order to facilitate the comparison between both scenarios.

As seen in the figure, total specific emission would maintain a downward trend throughout the whole period under analysis, with a 7% decrease compared to present values. Thus, mitigation actions would succeed in reversing the growing trend of total specific emission expected in the baseline scenario after the year 2005. Any way, it should be pointed out that such decrease achieved through mitigation actions is modest compared to 25% recorded in the last 25 years. As a decrease in this index only reflects the switching to less carbon content energy sources, the past achievements will be difficult to replicate in the future. Precisely, the spectacular fall in specific emissions since 1970 was achieved encouraging natural gas penetration and diversifying electricity generation technologies.

Given the present high natural gas share, few opportunities are left to replicate past achievements by resorting to the same mechanism. This in no way means that the higher energy requirements resulting from the economic growth cannot be met maintaining the energy service quality while reducing CO₂ emissions. Simply, the volume emitted per unit of energy used is not the right indicator to measure such achievement.

The comparison of specific emission curves from end-use sectors for both scenarios clearly illustrates such indicator's limitations, as improvements are minor in spite of a substantial emissions decrease. The situation is totally different in energy supply-

related activities, as after the year 2005 both curves shall totally differ due to changes in electricity supply strategies.

Figure 72   CO₂ specific emissions
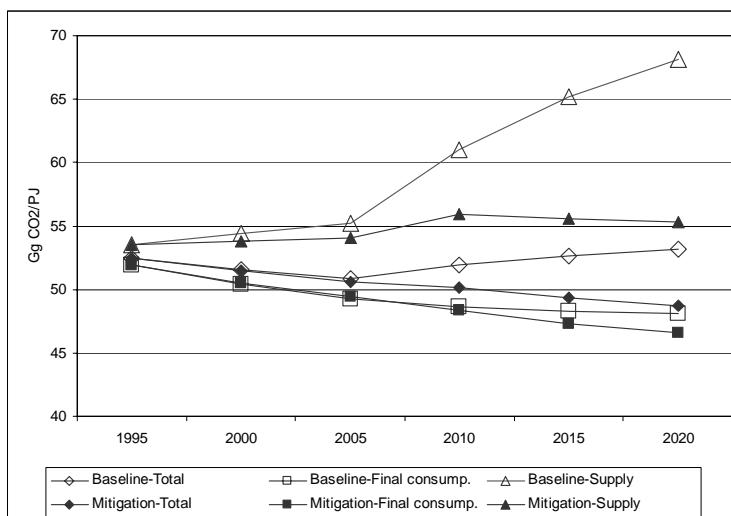
Stability in specific emission from supply in the mitigation scenario reflects that the present technology mix in electricity generation will be maintained preventing the 23% growth expected in the baseline scenario.

To better understand the origins and scope of such differences, the expected evolution of specific emission from power stations should be analysed in detail for both scenarios. Such analysis appears in Figure 73. Just like for the baseline scenario, two indicators were calculated. The first one, labelled as "Power plants" in the figure, represents CO_2 emission per unit of energy used in power stations (Gg of CO_2/PJ). The other curve represents the ratio between emissions and electricity generation (Gg of CO_2/TWh) and was labelled as "Electricity Generation".

Figure 73   Specific CO₂ emission from power plants
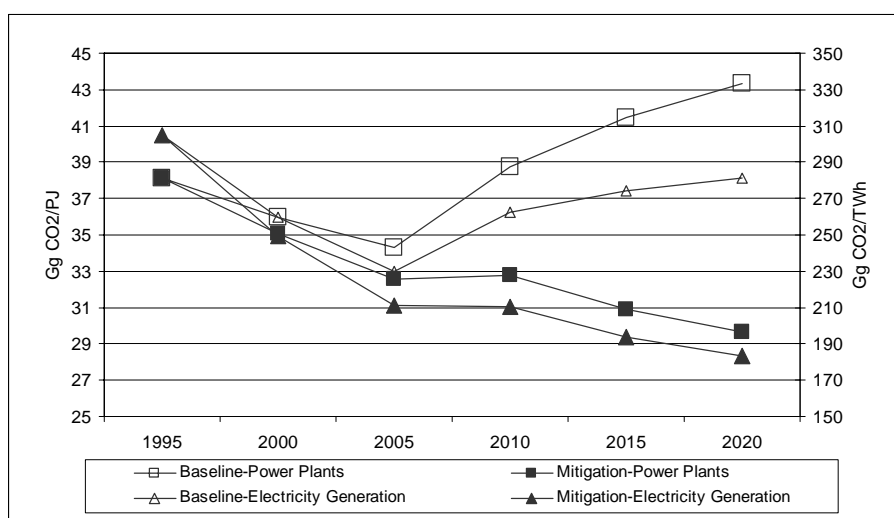
Until 2005, specific CO_2 emissions from power stations shall follow a very similar path in both scenarios, evidencing some rigidity in the medium term, although the clear

downward trend due to the completion of certain hydro and nuclear power stations presently under construction and efficiency improvements in fossil-fuelled power stations. The 5% reduction shown in the mitigation scenario compared to the baseline scenario would result from lower electricity demand and in turn less fuel burnt in thermal power stations.

The main difference will occur as from the year 2005. A different generating capacity expansion strategy shall not only prevent the specific emissions to increase, but retain the past downward trend until reaching in the horizon year a 31% lower value than in the baseline scenario.

When analysing the environmental efficiency of power plants in terms of their production (TWh of electricity generated), it is noted that the decrease taking place until the year 2005 is more pronounced than in the baseline scenario (31% compared to present values vis-à-vis 25% without mitigation actions).

The change in the electricity supply strategy would permit to maintain such downward trend throughout the period under analysis, achieving emissions reduction per generated kWh amounting to 40% at the end of the period and 30% when compared to the baseline scenario.

Also in this case, the ratio between the two curves (specific emissions measured with respect to energy used in power stations and to electricity produced) reflects the average efficiency of power plants. Hydroelectric generation's higher share in the mitigation scenario (with 80% performance) would permit to increase the generating facilities' average efficiency to reach 58% in the horizon year, i.e. three percentage points above that expected in the baseline scenario.

As pointed out when analysing baseline scenario, both reducing the heat rate of fossil-fuelled power stations and using extensively natural gas constitute true mitigation measures, even when they are included in the baseline scenario as part of companies' interest and their promotion does not call for explicit public powers' intervention.

An element that should be borne in mind when analysing the evolution of carbon dioxide emission from power stations is the influence of inter-country electricity trade. In a hydro/thermal mixed system like in Argentina, electricity exports imply increasing thermal generation to meet foreign demand. Consequently, it could be stated that from CO_2 emission mitigation standpoint in the Argentine territory, the exports' hypothesis assumed in the scenarios conspires against more substantial carbon dioxide emission savings. In spite of these higher emissions in Argentina, the savings in the importing country could be such that they resulted in a favourable balance for the "Importer-Exporter" pair. If so, and within a regional energy integration process, it would be interesting to explore the possibility of regional agreements to allocate such foreign trade environmental benefits equally among the parties.

Differently than specific emissions from power stations, end-use sectors' specific emissions would be very similar in both scenarios, as seen in Figure 74, which only includes sectors where mitigation measures were introduced (transport and industry

In case mitigation measures were applied for the transport sector, CO_2 emission per energy unit used would only be 3% lower than the baseline scenario expected value for the horizon year and 10% lower than present values. In spite of that, total emission from transportation would decrease by 37%. Total and specific emissions' different behaviour show that lower emissions mainly result from lower energy consumption

expected in the mitigation scenario rather than from structural changes in the type of energy source used.

Figure 74   CO₂ specific emissions from end-use sectors
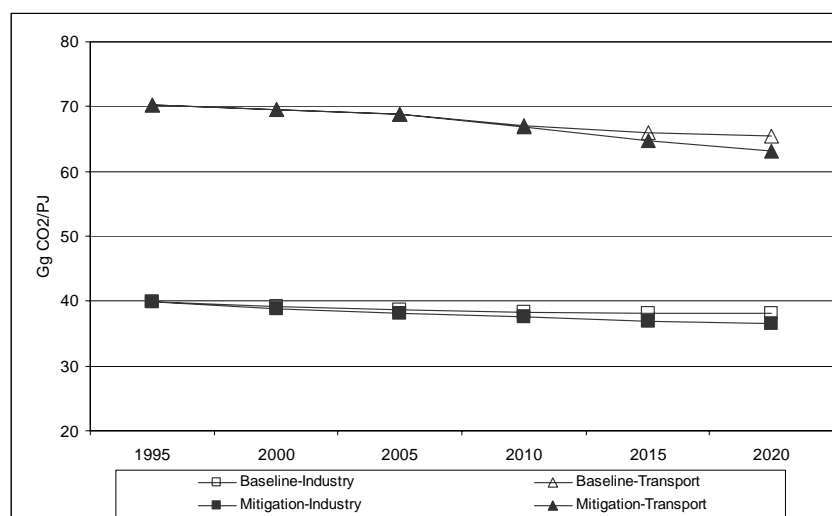
The industry portrays a similar situation. While total emissions in 2020 could drop 25% due to mitigation actions, specific emissions shall only decrease 3% compared to the baseline scenario. Anyway, the industry shall emit some 10% less CO_2 per energy unit used compared to present figures.

Energy and CO₂ emission pathways

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

The energy pathway graphically represents variations in the energy intensity of domestic economic activity (energy supplied per GDP unit) as a function of the economic evolution, measured by the per capita GDP. A similar curve can be plotted for CO_2 emissions, the emission pathway, representing the evolution of emission per GDP unit according to changes in the per capita product.

Figure 75 illustrates energy and carbon dioxide emissions' pathways for Argentina in the 1995/2020 period, for both scenarios, taking as index 100 the 1995 respective intensities.

As seen in the figure, throughout the next ten years mitigation measures jointly would allow to decrease the Argentine economy's energy intensity by an extra 3% on top the 16% expected in the baseline scenario. Therefore, in the medium term both the expected structural changes in the Argentine economy in favour of less energy-intensive activities and the natural trend to increase energy efficiency should have a stronger impact than mitigation actions themselves.

Mitigation actions would have a similar impact on the emission intensity, which should be added to the 18% expected in the baseline scenario by intensifying the use of less CO_2 emitting energy sources in the coming years. It should be pointed out that such downward trends could be expected in spite of the economic expansion, accounting for 30% increase in the per capita GDP.

Figure 75   Energy and CO₂ emissions pathways
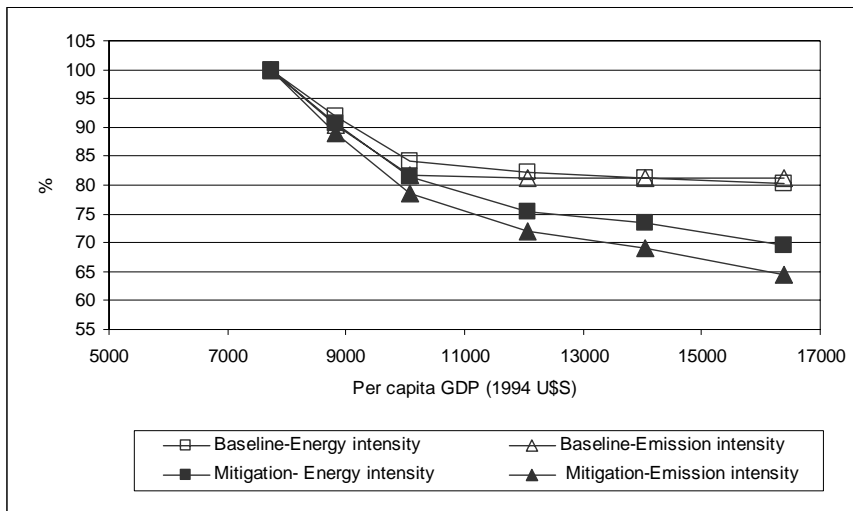
In the longer term their impact on energy intensity should increase, adding a reduction of over 10 percentage points to the drop expected in the baseline scenario. With respect to present values, the mitigation scenario energy intensity would drop over 30% as a result of technology innovation, structural adjustment and higher energy efficiency promotion.

The impact would be even greater for carbon dioxide emission intensity. In fact, whereas in the baseline scenario emission intensity is expected to stabilise at about 80% of present values, mitigation actions would lead to persistent emission abatement reaching 65% of the base year values in the horizon year.

By comparing emission intensity and specific emission expected behaviours, it can be gathered that the emission pathway permits to better capture the impact of energy savings on emissions.

The ratio between emission and energy pathways defines the specific emission pathway illustrated in Figure 76. As seen, specific emission evolution in both scenarios is totally divergent as of the year 2005. While in the baseline scenario the growth in the last 15 years of the period would more than offset the reductions expected in the next 10 years, in the mitigation scenario the downward trend would continue throughout the whole period to reach a 7% abatement from present values.

However, this indicator is unable to reflect mitigation measures' true impact, as the reduction in energy intensity is not gauged.

5.2   Methane emissions

Total methane emissions from the energy system, arising from natural gas leaks during such fuel's production, transport and consumption, as well as in light liquid fuels' volatilisation, shall not exhibit significant differences in both scenarios.

In the mitigation scenario energy supply's share in methane's total emissions shall decrease, accounting for only 0.2% in the year 2020. As stated when commenting

baseline scenario results, the fulfilment of such forecast shall depend on the effective control of gas vented in gas fields, as assumed in building the scenarios.

Figure 76   CO₂ specific emission pathway
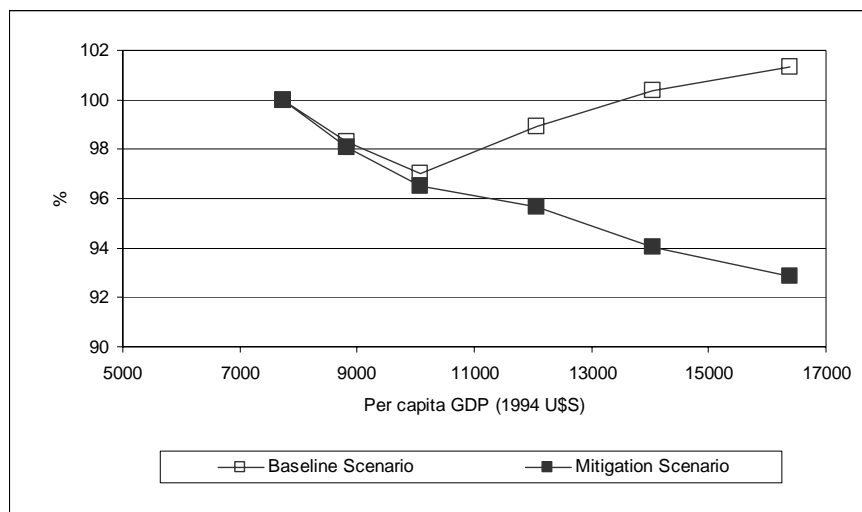
In spite of the expansive context of gas production and consumption, throughout the period natural gas industry's emissions (considering losses and venting) would be lower than those recorded in 1995.

Consequently, in this case too, methane emissions' evolution shall mainly originate in end-use sectors. In fact, future CH_4 emission growth shall be driven by the transport sector, whose share shall steadily grow to about 97% in the horizon year, compared to the present 95%, values similar to those expected in the baseline scenario.

Anyway, the similarity in methane emissions in both scenarios occurs amidst a quite different context regarding energy consumption for transportation. In order to grasp the true significance of such facts, methane specific emission per energy unit used for transportation was calculated. The evolution for both scenarios is illustrated Figure 77.

Figure 77   CH₄ specific emission from transportation
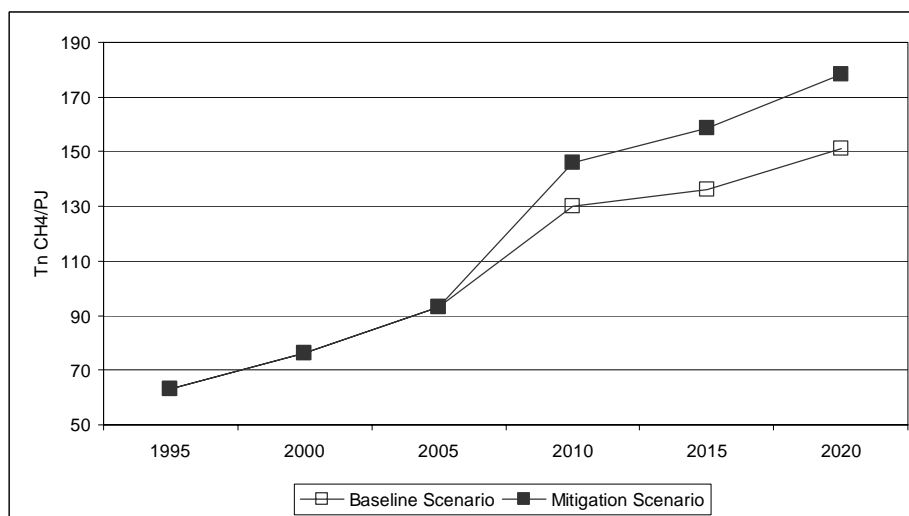
As seen, mitigation scenario's specific emission would grow faster than in the baseline scenario after the year 2005, to become 18% higher in the horizon year. Such evolution shall result from CNG higher penetration in the mitigation scenario. It could be stated that higher methane emissions are the "price" paid to reduce CO_2 emissions. In any way, and in spite of methane's greater global warming potential, the balance of CNG use would be positive regarding its contribution to climate change mitigation.

5.3 NO_x emissions

Differing from baseline scenario expectations, the evolution of NO_x emissions would be defined mainly by two sectors in future: transport a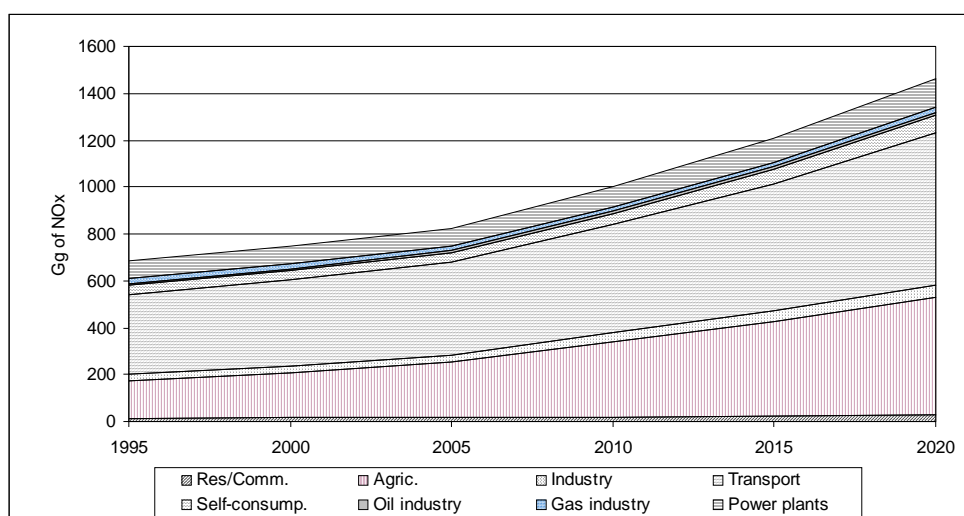nd agriculture and cattle breeding, as the decrease in thermal power stations' electricity generation would notably reduce power plants' share in total NO_x emissions, as seen in Figure 78.

Figure 78   Total NO_x emissions

It should be remarked, however, that the expected NO_x emission abatement in the electricity sector is solely due to changes in the generating technology mix and does not involve the benefits derived from low-NO_x-emission burners in gas turbines. This type of burners is also expected to be incorporated in the mitigation scenario, in the medium term as a result of decisions already made by power operators, and in the long term as a complement of hydro and nuclear generation.

As pointed out when describing baseline scenario results, the NO_x emissions from power stations in this study are fully comparable to that estimated in the GHG inventory report for Argentina, without involving lower emission factors measured by the ENRE at new power stations' chimneys.

Leaving aside the discrepancy that might exist in NO_x emitting factors and the need for reviewing the present study's estimates, a change in electricity supply strategy should result in about 40% total NO_x emission abatement from power stations in the horizon year between both scenarios.

Reducing NO_x emissions from power stations and transportation by decreasing petroleum products' use highlights the importance of agriculture and cattle breeding activities in total NO_x emissions in the mitigation scenario. In fact, this sector's NO_x emissions might account for 34% of total emissions in the year 2020, versus the present 23%.

214

Even when total NO_x emissions from transportation would be 18% lower than those expected in the baseline scenario for the horizon year when mitigation measures are adopted, such emissions would still account for 45% of the total.

5.4   CO emissions

Mitigation measures in the transport sector shall cause 34% abatement in the sectoral emissions expected in the baseline scenario for the year 2020. Given the high share of transportation in total CO emissions, the global effect of such measures shall be a persistent drop in total CO volumes emitted by the energy system, reaching only 82% of present figures in the horizon year.

Such behaviour of transport sector shall contrast with the evolution of emissions from the agriculture and cattle breeding sector, whose share would rise from the present 4% to 14% in the year 2020.

Mitigation costs

1 Introduction

Assuming that the actions have the purpose of cutting down greenhouse effect gas emission or increasing the capacity of the sumps, this implies the utilisation of resources which may have alternative uses. The aim of the present chapter is to make a preliminary estimation of the costs which actions to mitigate such gases would have.

It has already been made explicit that the mitigation scenario presupposes the existence of an explicit policy and of a strategy to develop projects which would not be elaborated in the base scenario. The so-called mitigation costs for the series of projects analysed are thus the cost difference between both scenarios.

The effects of the mitigation projects are manifold: economic, social, environmental. Some of the so-called economic effects maybe pinpointed, quantified, appraised and monetised, while others may reach the identification and quantification level but may not be converted into monetary units. Either they be monetised values or not, the alternatives to be analysed and compared have multiple associated costs and benefits. The knowledge —as much thorough as possible— of such costs and benefits represents a basic input to determine an impact vector which may provide information for decision taking. Economic as well as social and environmental effects fall into this category of non-monetised or non-monetisable impacts.

The analysis of mitigation costs is in general restricted to economic costs which may be pinpointed, measured, quantified, appraised and monetised, whether the cost analysed is expounded at market prices or at accounting prices. The difference between one alternative and the other is associated to the flows identified, according to whether the viewpoint is individual or collective and to the appraisal of such flows, according to whether the market prices show the true lack of resources or goods under evaluation or not, or simply to the existence of such prices.

Since the viewpoint with which the Climate Change issue is considered is not the individual viewpoint but the collective one, the methodologies usually in practice suggest that costs and benefits should be calculated analysing the effect of the projects from an approach of the economy as a whole and not from an individual viewpoint. Such benefit-cost analysis presupposes the need to modify the "financial" flows of the projects and to use "Accounting Prices" for the monetisation of the positive and negative effects.

Such proposal presents three questioning levels or dimensions:

The least important one is the very difficulty implied by the estimation and calculation of accounting prices and the explicit or implicit hypotheses which their determination represents.

At a second level, we have the underlying analysis level, partial, in which all relations between the project and the rest of the socio-economic system may only be expressed through the price system. The possibility of a systemic analysis which may make

explicit the mutual inter-relations and the effects in space and time may not be internalised by traditional methodologies.

The element of the highest relevance is associated to the very conceptual theoretical framework, its hypotheses, assumptions, consequences and implications. The need to predetermine a goal function which is collective or of a collective social wellbeing to which such accounting prices should refer, the fact that the distribution of income is data which lies outside the analysis and the estimation of prices within the framework of a static model before a dynamic reality have represented and represent elements of sufficient weight which call for caution and do not advise the use of this type of analysis for taking decisions which may support policies or strategies associated to the problem which concerns us or to any other issue related to national development.

That is the reason why the present chapter is based on the estimation of monetisable effects in market prices, assuming a financial viewpoint for the calculation of such effects. Even under this hypothesis, the evaluation of mitigation costs proves difficult and uncertain given the number of elements involved, the limitation of available information and the lack of knowledge or partial knowledge of every analysis associated to a relatively distant future.

Moreover, it is assumed that benefits are associated to goals to be achieved, and that the relevant thing is to reach such goals at the lowest possible cost. The analysis is thus restricted to the calculation of costs through the application of the cost-effectiveness principle.

Finally, only those costs associated to the projects in a direct way are included as identified costs, that is, direct costs of the alternatives. Consideration has not been given to indirect costs, implementation costs (administrative, obstacle-removal, transaction, etc.), macroeconomic costs (distributive impacts, impacts on the foreign sector, on the GDP, on public finances, etc.) and those which , in general, are not expressed in the market.

Hence, the results of the few examples shown must be considered as highly preliminary and associated to what could be seen as steps or minimum levels of such costs.

The results obtained for examples of the transport, industry, electricity generation and cogeneration are given below.

2   Transportation

2.1   Introduction

Together with traffic organisation measures —circulation regulation, improvements in the traffic flow, increase of average speed, improvement of roads and new highways—, mitigation measures are included which refer to technical improvement of means of transport (specially automobiles), replacement among means of transport (higher penetration of public transport) and replacement among sources, as well as an improvement in the utilisation factor.

Without attempting to be comprehensive and exhaust all options, the estimations of mitigation costs have been carried out for the actions of higher relevance as regards the purpose —cutting down CO_2 emission— and additional benefits.

The difficulty in obtaining precise information, the uncertainty with respect to the evolution of future values and the lack of knowledge on costs at commercial level for options which are still within the grounds of research and development imply that the calculations and results submitted should be deemed quite preliminary and subject to specific studies which may allow to obtain higher precision on costs and their probable future evolution.

On the other hand, the magnitudes included in the estimations solely refer to the so-called direct costs. Indirect costs, policy-implementation costs, the necessary financing devices and their costs —among other elements— have not been considered, and this allows to assert that calculated costs will most surely underestimate real magnitudes. An estimation using a different methodological approach —benefit-cost analysis— could include the benefits and disadvantages from the viewpoint of the economy as a whole using accounting prices and including all costs and benefits associated to each action. In this last case, results could differ substantially from those reached through financial analysis. The necessary additional hypotheses, the difficulties associated to the estimation of accounting prices, and the implication of such methodological approach leave the possibility of expounding such estimations outside the scope of the present project, and advise to maintain the analysis at market price level.

In the case of the public transport sub-sector, examples of the three options will be submitted, while in the case of cargo transport, examples of substitution among means will be specified.

2.2   Public transport

2.2.1 Technical improvement

The years of service of the total number of vehicles (especially automobiles) poses a situation of significant inefficiency with respect to average consumption per vehicle. Considering that the improvement in the efficiency of new automobiles is increasing at great speed, it is estimated that a reduction in the service years of the total number of vehicles would have positive effects through a more rational use of energy and a reduction of consumption and emission.

With this in mind, an analysis was carried out of the impact which an increase in the percentage of new vehicles would have in the total number of vehicles within the mitigation scenario for the years 2010 and 2020. Such analysis was carried out for automobiles and taxis and for all types of fuel currently in use —gas, diesel oil and CNG— under the following hypotheses (Table 57 and Table 58):

Table 57   Hypotheses for automobiles

Automobiles	2010 Gasoline	2020 Gasoline	2010 Diesel oil	2020 Diesel oil	2010 CNG	2020 CNG
Investment cost	15200	13680	18600	16740	16720	15048
Useful Life	7	7	7	7	7	7
Operations & maintenance cost	3%	3%	3%	3%	3%	3%
Consumption (l/Km)	0.0656	0.044	0.052	0.04	0.072	0.048
Km/year	15000	15000	20000	20000	20000	20000
Fuel price	1.096	1.28	0.5411	0.631	0.384	0.448
New automobiles (%)	52%	75%	41%	60%	53%	70%

Table 58   Hypotheses for taxis

Taxis	2010 Gasoline	2020 Gasoline	2010 Diesel oil	2020 Diesel oil	2010 CNG	2020 CNG
Investment cost	16720	15048	20064	18058	18240	16416
Useful Life	7	7	7	7	7	7
Operations & maintenance cost	3%	3%	3%	3%	3%	3%
Consumption (l/Km)	0.0656	0.044	0.052	0.04	0.072	0.048
Km/year	50000	50000	50000	50000	50000	50000
Fuel price	1.096	1.28	0.5411	0.631	0.384	0.448
New automobiles (%)	52%	75%	41%	72%	53%	70%

As presented in Table 59 and Table 60, mitigation costs were obtained for the six cases analysed as a result of the hypotheses established. Costs show a strong sensitivity to the useful life assumed for the vehicles and to the annual kilometres run. Performance improvements (fuel consumption per kilometre) assumed for the year 2010 vary from 30 to 34% with respect to average consumption at the base year. For the year 2020, performances improve from 38 and 50%.

Table 59   Mitigation results and costs for automobiles and taxis, year 2010

Year 2010	Discount Rate: 3%		Discount Rate: 10%	
	CO2 Ton/year	US$/Ton	CO2 Ton/year	US$/Ton
Automobiles Gasoline	954799	843	954799	1442
Automobiles diesel oil	323028	1432	323028	2165
Automobiles CNG	234359	892	234359	1373
Taxis - Gasoline	34814	201	34814	400
Taxis - Diesel oil	26794	499	26794	815
Taxis - CNG	21988	285	21988	495

Table 60   Mitigation results and costs for automobiles and taxis, year 2020

Year 2020	Discount Rate: 3%		Discount Rate: 10%	
	CO2 Ton/year	US$/Ton	CO2 Ton/year	US$/Ton
Automobiles Gasoline	2173319	343	2173319	755
Automobiles diesel oil	944475	1056	944475	1637
Automobiles CNG	638957	1184	638957	1586
Taxis - Gasoline	59682	-99	59682	38
Taxis - Diesel oil	128192	317	128192	568
Taxis – CNG	106714	172	106714	345

The costs associated to a significant modernisation of the total number of vehicles are considerable, although —and particularly in the case of private automobiles— the reduction in emission would represent more than 1,500,000 tons of CO2 per year in the medium run (2010) and nearly 3,800,000 tons of CO2 per year in the long run (2020). The average cost of such reduction —at a discount rate of 5% and for the medium run— would be of US$ 1144/ton, leaving the option outside reasonable ranges for

implementation. In the long run (2020), such unit cost would come down to US$ 790/Ton of CO_2, still maintaining high values with respect to other alternatives.

Figure 79 sums up the data obtained for the medium run (2010) for 3% and 10% rates. The lower unit cost is associated to taxis using gas, while higher values refer to automobiles using diesel oil.

Figure 79 Mitigation cost curve, year 2010
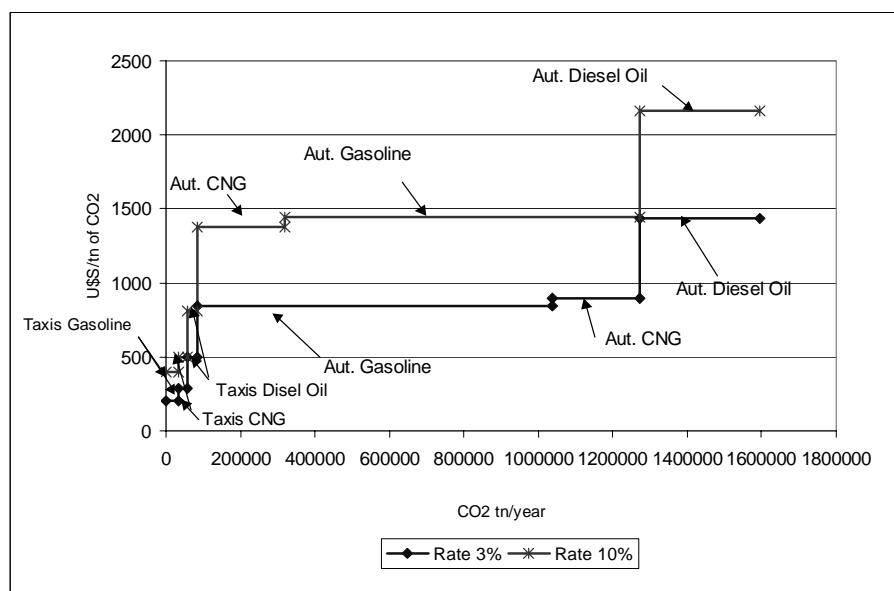
With respect to the long run (2020), we notice negative costs in the case of taxis using gas (a very low number in such horizon), while higher costs refer to automobiles using diesel oil and CNG (Figure 80).

Figure 80   Mitigation cost curve, year 2020

221
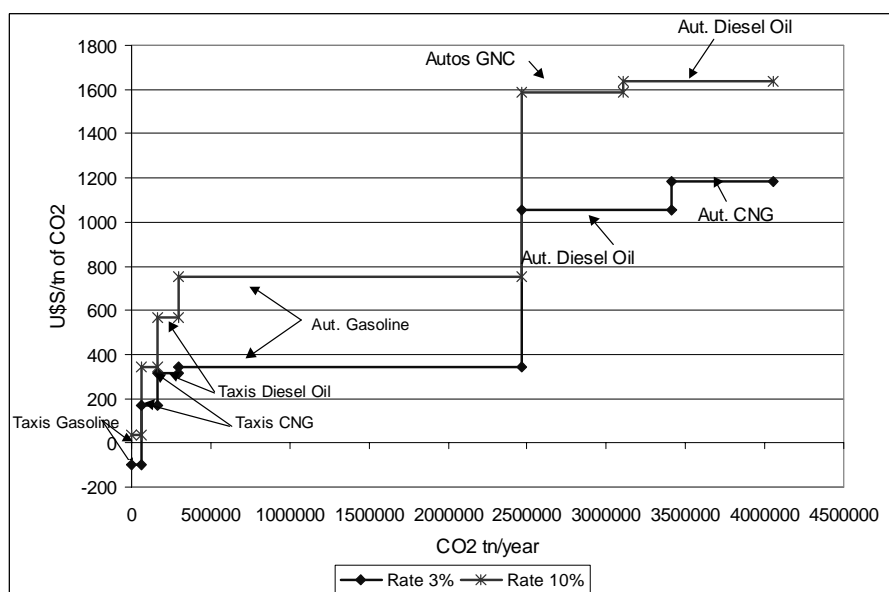
2.2.2 Substitution among sources

Substitution among sources within each of the means represents a highly interesting option, especially in the case of already-existing sources which imply improvements in performance and lower emission. Diesel oil and CNG fall into this situation as gas substitutes. The new sources considered have been hydrogen and electricity.

For this purpose, an analysis was carried out of the impact differential there would be when substituting within the mitigation scenario a higher proportion of the total number of automobiles and taxis using gas with diesel oil, CNG, hydrogen and electricity. For this, we have assumed a certain penetration of the mentioned sources so as to reach rising share percentages in 2010 and 2020.

It is necessary to make clear that in the case of hydrogen and electricity, this is a highly preliminary and speculative estimation given the strong uncertainty which exists as regards the true costs of applying such sources to transport, particularly individual human transport. Hence, results should be taken as merely indicating a probable trend in magnitudes or magnitude orders of the economic values associated to technologies.

Hypotheses for the case of automobiles and taxis for the years 2010 and 2020 are summarised in Table 61 and Table 62.

Table 61   Hypotheses for automobiles

Automobiles	2010 Gasoline	2020 Gasoline	2010 Diesel oil	2020 Diesel oil	2010 CNG	2020 CNG	2020 Hydr.	2020 Elect.
Cost vehicle	15200	13680	18600	16740	16720	15048	35000	35000
Useful life	7	7	7	7	7	7	7	7
O & M - % accord. to cost vehicle	3%	3%	3%	3%	3%	3%	3%	3%
Consumption (Unit/Km)	0.0656	0.044	0.052	0.04	0.072	0.048	0.076	0.109
Km/year	15000	15000	20000	20000	20000	20000	20000	20000
Fuel price	1.096	1.28	0.5411	0.631	0.384	0.448	1.2	0.11
Total number automobiles	3881590	3762500	1415100	2346000	677500	1348100	160600	80300

Table 62   Hypotheses for taxis

Taxis	2010 Gasoline	2020 Gasoline	2010 Diesel oil	2020 Diesel oil	2010 CNG	2020 CNG
Cost vehicle	16720	15048	20064	18058	18240	16416
Useful life	7	7	7	7	7	7
O & M - % accord. to cost vehicle	3%	3%	3%	3%	3%	3%
Consumption (Unit/Km)	0.0656	0.044	0.052	0.04	0.072	0.048
Km/year	50000	50000	50000	50000	50000	50000
Fuel price	1.096	1.28	0.5411	0.631	0.384	0.448
Total number of taxis	29400	15900	46900	80500	54600	110500

As in the previous cases, costs show a strong sensitivity to the useful life assumed for the vehicles and to the annual kilometres run.

In the medium run —2010— the substitution of gas by diesel oil and CNG poses negative costs for all discount rates considered (Table 63 and Table 64). The values reached confirm the trend shown by the market: in the case of automobiles and taxis, a strong penetration of diesel oil, with a lower penetration of CNG, favoured by highly

convenient relative prices for such substitution. The yearly CO2 emission which may be avoided through these actions could exceed 363000 tons.

*Table 63   Mitigation results and costs for automobiles and taxis, year 2010*

Year 2010	Discount rate: 3%		Discount rate: 10%	
Automobiles	CO2 Ton/year	US$/Ton	CO2 Ton/year	US$/Ton
Gasol. by DO	84627	-684	84627	-382
Gasol by hydrogen	191867	954	191867	1168
Taxis				
Gasol. by DO	6955	-1401	6955	-1268
Gasol. by CNG	49568	-476	49568	-467

Table 64   Mitigation results and costs for automobiles and taxis, year 2020

Year 2020	Discount rate: 3%		Discount rate: 10%	
Automobiles	CO2 Ton/year	US$/Ton	CO2 Ton/year	US$/Ton
Gasol. by DO	180078	-1011	180078	-709
Gasol. by Elect.	248498	410	248498	625
Gasol. by hydrogen	496996	961	496996	1175
Taxis				
Gasol. by DO	20107	-2493	20107	-2367
Gasol. by CNG	161497	-548	161497	-540

Figure 81 sums up the data obtained for the medium run (2010) for 3 and 10% rates. The lower unit cost is associated to taxis using diesel oil.

Figure 81   Mitigation cost curve, year 2010
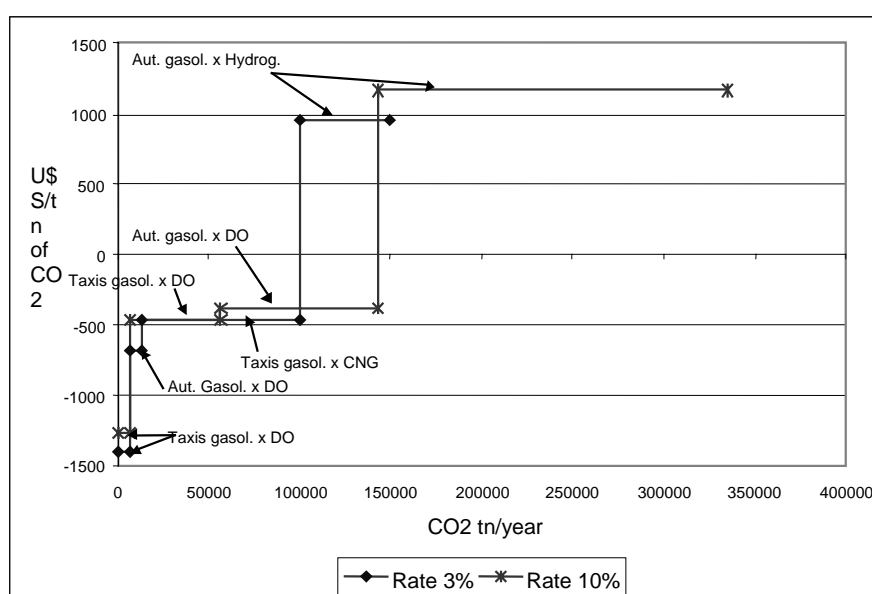
As regards the long run (2020), there are also negative mitigation costs for diesel oil and CNG, with values even lower than those reached for the medium run. Nevertheless, both the hydrogen alternative and electricity show very high costs per ton of CO2 for 5% rates. In the case of hydrogen, it rises to US$/ton CO2 1020, while in

the case of electricity to US$/Ton CO2 469. In the long run, a reduction of 1100000 Tons of CO2/ year could be achieved (Figure 82).

Figure 82   Mitigation curve cost, year 2020
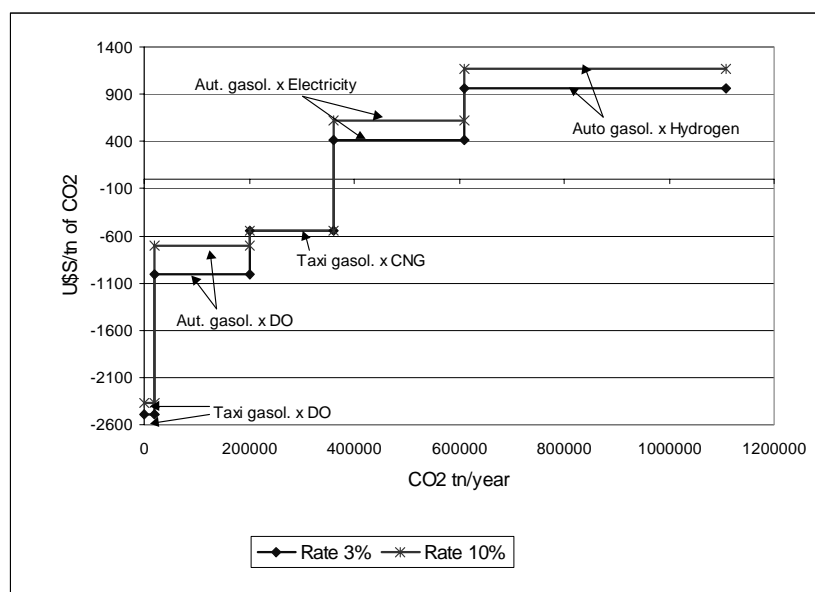
Moreover, we include the results obtained as from the hypothesis of substituting diesel oil with CNG in public transport (urban buses) in the medium and long run. Table 65 shows the hypotheses associated to each alternative:

Table 65   Hypotheses for buses

Buses	2010 Diesel oil	2020 Diesel oil	2010 CNG	2020 CNG
Investment	150000	150000	165000	160000
Useful life	5	5	5	5
O & M	4500	4500	4950	4800
Consumption (Unit/Km)	0.292	0.29	0.216	0.216
Km/year	200000	200000	200000	200000
Fuel price	0.541	0.631	0.384	0.448

Both in the medium and the long run, the substitution of diesel oil by CNG poses negative costs in accordance with the hypotheses carried out. Such negative costs are given for the range of discount rates used (Table 66).

Table 66   Mitigation results and costs for urban buses

Buses DO by CNG	Discount rate: 3%		Discount rate: 10%	
	CO2 Ton/year	US$/Ton	CO2 Ton/year	US$/Ton
2010	928358	-183	928358	-172
2020	1923816	-230	1923816	-220

The emission avoided through these measures would reach 928000 Ton CO2/ year in the medium run and could rise to 1924000 in the long run. Figure 83 shows the total curve including all options.

Figure 83   Mitigation curve cost, year 2020

Figure 83   Mitigation curve cost, year 2020
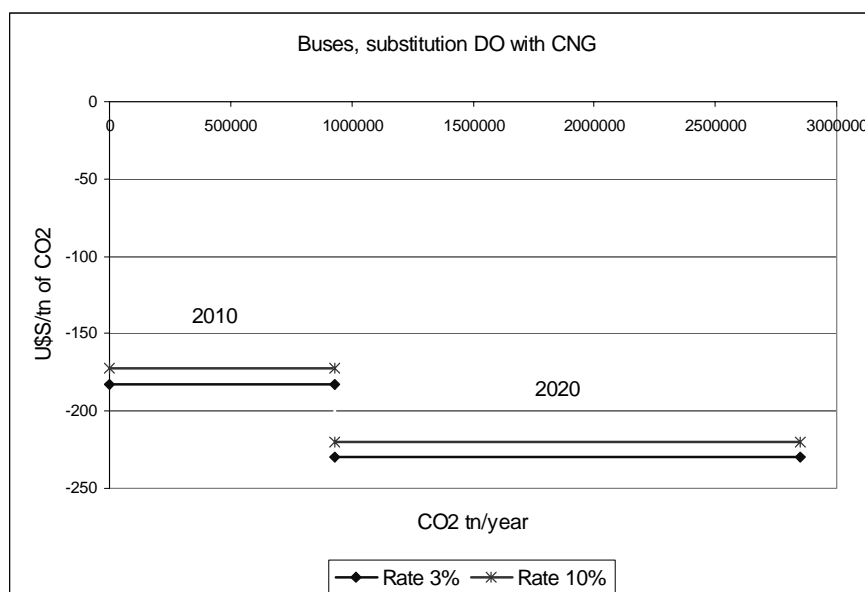
2.2.3 Substitution among means

Finally, we present the hypotheses and results obtained from the assumption that there is a substitution among different means of transport of people. On the one hand, a higher role is given to public transport, assuming that the use of private automobiles falls and that the demand is met by public transport (buses). On the other hand, an analysis is made of the mitigation potential of the substitution of buses by exclusive track vehicles (subway, electric train, or diesel oil train).

In principle, it has been estimated that a bus is capable of substituting up to eighty automobiles circulating daily. Under these conditions, the alternative of public transport proves to be quite cost-effective. At a discount rate of 5%, the cost per ton avoided would reach US$ 957. Even if we assumed lower substitution percentages, the alternative is still cost-effective and maintains negative values. This action is, nonetheless, one of the most difficult ones to achieve considering the mentality and culture of the consumers. Actions such as circulation banning methods, substantial improvement of public transport —with additional costs— would be necessary, together with adequate measures to achieve the adherence of car drivers.

Contrary to what happens with the substitution of automobiles, the possibility of achieving a higher penetration of trains and subways has substantial additional costs (Table 67 and Table 68). Even for very low discount rates, none of the mentioned alternatives registers costs lower than US$/ton CO_2 137 (train running with diesel oil at a 3% rate), reaching figures closer to US$/Ton CO_2 2000 (Subway at a 12% rate).

Table 67   Mitigation results and costs for substitution among means, year 2010

Year 2010	Discount rate: 3%		Discount rate: 10%	
	CO2 Ton/year	US$/Ton	CO2 Ton/year	US$/Ton
Bus by subway	157657	726	157657	1560
Bus by train	117260	-167	117260	45
Bus by elec. train	150149	82	150149	414
Automob. by bus	97420	-930	97420	-906

Table 68   Mitigation results and costs for substitution among means, year 2020

Year 2020	Discount rate: 3%		Discount rate: 10%	
	CO2 Ton/year	US$/Ton	CO2 Ton/year	US$/Ton
Bus by subway	840837	859	840837	1698
Bus by train	234520	-212	234520	-45
Bus by el. train	600598	-111	600598	95
Automob. by bus	125272	-1942	125272	-1990

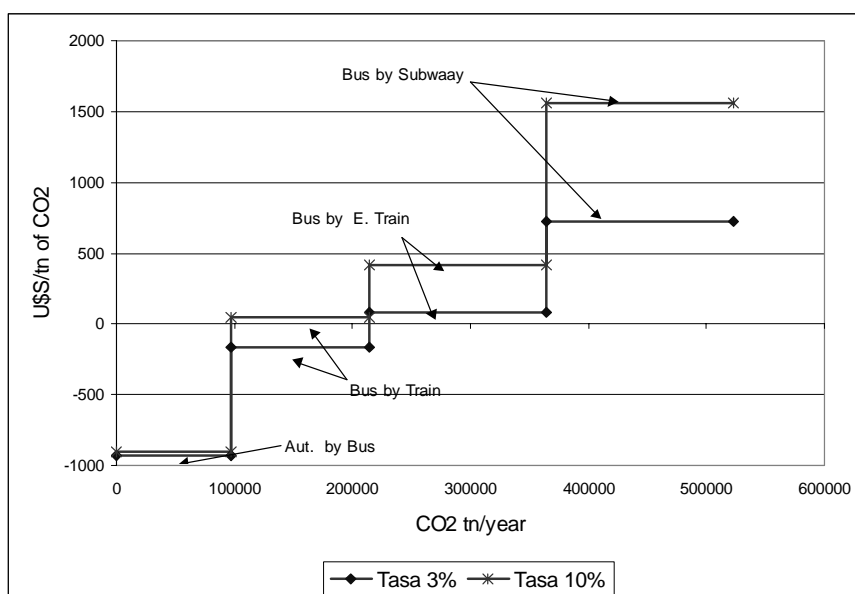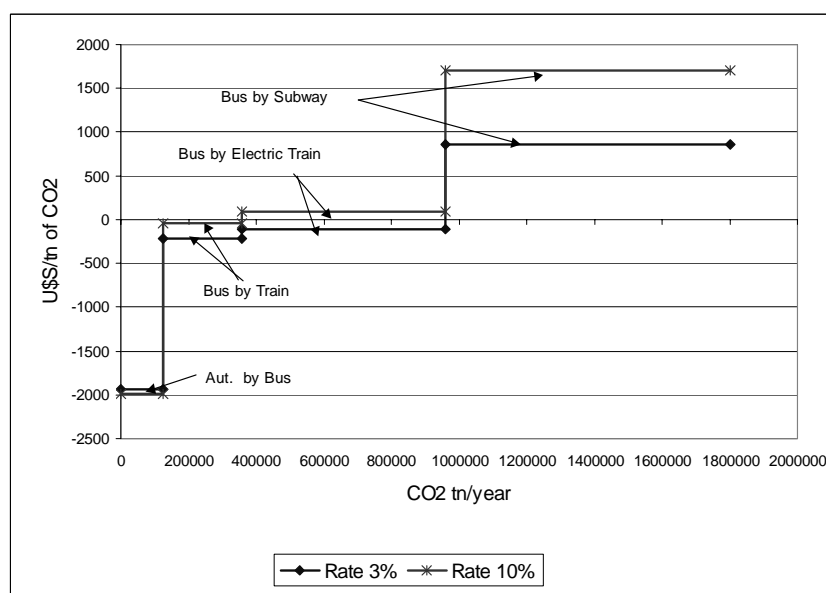*Figure 84   Mitigation cost curve for substitution among means, year 2010*

Figure 85   Mitigation cost curve for substitution among means, year 2020

Consequently, these seemingly-interesting alternatives from the point of view of their being quite clean technologies (subway) may only be implemented with very high additional costs, and it needs to be emphasised that only direct costs have been calculated, without including implementation and other costs.

The curves corresponding to the four alternatives and two periods have been put in Figure 84 and Figure 85 for discount rates of 3 and 10%.

2.3   Cargo transport

In the case of cargo transport, we present as an example the substitution of trucks by trains using diesel oil as fuel source.

An improvement of the fixed railroad infrastructure has been assumed, together with the renewal of rolling materials so as to be able to substitute a significant number of trucks. The hypotheses with respect to costs associated to trains and trucks are presented in Table 69 and Table 70.

Table 69   Hypotheses for trains

Train	2010	2020
Km of railways	1000 Km	2000 Km
Cost per Km	US$ 600000	US$ 600000
Locomotive	US$ 1500000	US$ 1350000
Freight car	US$ 40000	US$ 36000
Consumption	5.75 l/km	5.75 l/km
Fuel price	0.54 US$/l	0.54 US$/l
Trains	40	120

Table 70   Hypotheses for trucks

Truck	2010	2020
Units	2400	7200
Cost per Unit	US$ 175000	US$ 157500
Km year	60000	60000
Consumption	0.29 l/km	0.29 l/km
Fuel price	0.54 US$/l	0.54 US/l

The results in emission reduction and costs are summarised in the following table:

Table 71   Mitigation results and costs for substitution in cargo transport

	Discount rate: 3%		Discount rate: 10%	
	CO2 Ton/year	US$/Ton	CO2 Ton/year	US$/Ton
2010	70285	-1071	70285	-775
2020	210855	-1143	210855	-986

As figures show, this alternative proves highly attractive, since it presents negative costs for both periods and rates.

Figure 86 Mitigation cost curve, years 2010 and 2020
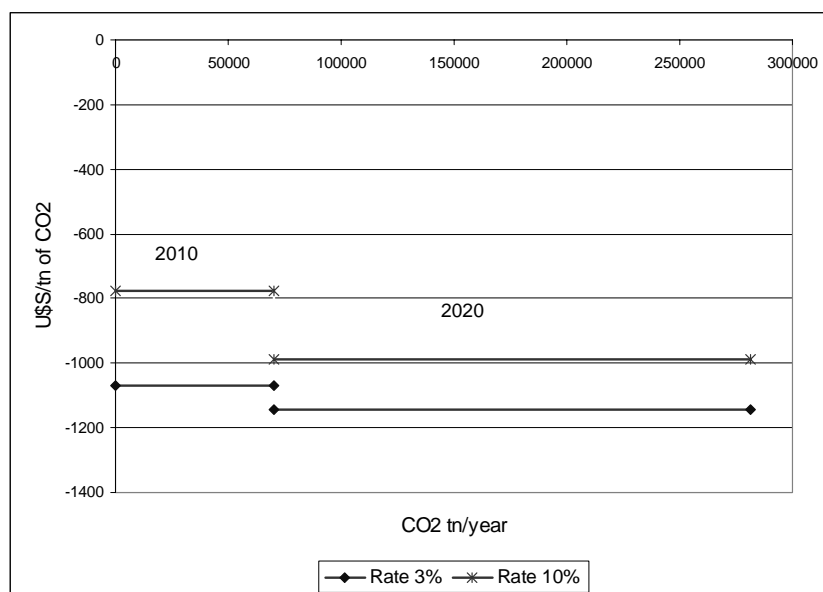
3   Industry

3.1   Considerations on technological changes

Following, the major technological changes expected for the branches selected are briefly described, corresponding to the "state-of-the-art" in the projection years. Additionally, the unit investment costs are explained as well as the sources from which such information was taken.

3.1.1 Pulp and paper

First, the size of the new plants to be installed should be considered, whose scale will be close to 200/300,000 Tons/year for pulp and 150/250,000 Tons/year for paper. In such respect, it should be reminded that presently domestic plants have a production capacity ten times lower than the most advanced plants world-wide.

The new plants' technologies involve considerable investments, e.g.:

1. Those pertaining to new pulp bleaching processes (the use of hydrogen peroxide is much more expensive than chlorine).

2. The decrease in the use of chlorine in the pulping process, with investments of up to 13% the cost of a 300 million dollars production line.

3. The addition of delignification stage between pulping and bleaching, using oxygen or eventually ozone (with a cost of about 6% of the production line cost).

Also, cogeneration systems' intensive use is considered for electricity and thermal energy, considering the high share of electricity self-production in the paper industry, as analysed under a different heading in this chapter.

Among the most outstanding advances in the new technologies, the following should be mentioned: paper machines' computerised control and regulation which results in higher productivity.

Heat conservation and recovery devices at different stages of the processes, e.g.: boilers' exhaust gases residual heat recovery, the recovery of process steam condense, the incorporation of economisers and air preheats in boilers, the use of "flash" steam and the enhancement of the use of "black liquor" as fuel for boilers, should be mentioned among the most efficient for process' energy savings.

Among the information sources that contributed to the elaboration of this summary, we should mention Asociación Argentina de Celulosa y Papel (Pulp and Paper Argentine Association) and qualified experts in the actual or prospective technologies used in such branch.

Equally valuable was the assessment by professionals from plants and equipment suppliers for the local industry.

On the basis of the information obtained, a mean investment cost of U$S 1,500 per Ton of annual production capacity was estimated, considering present plants' production structure, the various types of cellulose and paper produced and the technologies considered for the short and medium term.

3.1.2 Cement, lime and gypsum

This sector used over 8% of the industrial sector's energy consumption while its energy incidence exceeds 17% in the industry's cost structure.

Among the various technologies still in use at international level, only the "dry process" exists in the country, although each production plant exhibits its own characteristics.

Among improvements to be introduced, flash precalcining should be mentioned. The addition of the flash static furnace permits the use of relatively short rotary furnaces, which require half the calories used by conventional ones. The specific energy consumption obtained permits to achieve the lowest dry process values.

Another important improvement refers to energy savings in combustion, to be achieved through:

1. Regulation of primary air in the furnace burner.
2. The control of flame, principally seeking to eliminate nonburned substances.
3. Use of the clinker cooler exhaust air.
4. Use of flying ash with a high content of nonburned substances, incorporating such ashes to crude cement (obtaining up to 600 kilocalories per kilogram of ash).

The heat exchange technology in upstream gas suspension, a system called "Suspension Preheater" (SP) shall also be incorporated; as well as clinker precrushing and the use of roller press which will yield electricity savings of around 30%, and second and third generation separation plants.

Considering technological improvements and based on the information obtained from the Asociación Argentina de Productores de Cemento Portland (Cement Utilities Association), a mean investment cost of U$S 110 per Ton of annual production capacity was estimated for the new technologies.

3.1.3 Bovine cattle slaughterhouses and meat packing houses

In order to perceive the amount of investments required in this sector, the present technological development should be understood. In such sense, only the exporting meat packing houses have an up to date technological development in line with international standards —especially as regards health and safety— although their production level only reaches 25% of the beef production, 60% for foreign markets, and the remaining 40% for local consumption.

The businesses responsible for over 75% of beef production and/or by-products have to consider an intensive investment in this scenario to succeed in streamlining their plants and attaining acceptable levels of quality, productivity and efficiency.

Changes to be sought in the sector are not limited to technological improvements. They also include geographic relocation measures, changes in the scale of plants, and, fundamentally, spaces in cold storage chambers with last generation equipment.

Among the technological improvements to be introduced, the optimisation of airing chambers can be mentioned; use of evaporating condensers, heat pumps, and also absorption cooling systems. Adopting computerised production and cold consumption control and installing electronic humidifiers.

Information sources on the state-of-the-art and investment costs have been numerous, given the large variety of businesses and the wide mix of products offered in the market. The most accurate references on this sector were obtained from the Asociación Argentina de la Industria de la Carne (Meat Argentine Industries Association) and major companies of the sector.

The most salient information on investment costs was obtained from the Centro de Estudios de la Producción (Production Study Centre), the Secretariat of Industry, Commerce and Mining (ME y OSP). The Production Study Centre reported on the latest investments in the meat packing industry, with major investments to improve competitiveness.

On the basis of the information received, the investment cost to expand annual production capacity, using latest generation technologies would amount to 947 U$S/Ton.

3.1.4 Vegetable oils and fats

It has already been mentioned that this sector use up to date technologies in the country, to the point that the plants established in the last decade exhibit top efficiency and productivity levels in the international ranking.

A percentage of installed capacity, however, admits innovations and improvements to reduce energy consumption. Amongst them, the following can be mentioned:

1. Using steam economisers in exchangers using latent heat of gases from the desolventiser-toaster (DT).

2. Heating the solvent using DT gases latent heat after passing through the economiser.

3. Resizing surface condensers to reduce the cooling water level.

4. Reducing the installed electric power using hydraulic couplings.

On the other hand, the fact that 75% of production is exported drives the constant streamlining of the industry. Regardless of such fact, specialisation is expected to grow as well as the size of plants.

Research on investment costs focused on the Cámara de la Industria Aceitera (Oil Industry Chamber) and on various sector companies, also on suppliers of turnkey equipment and plants for the oil industry.

Although plants' output is expressed by their daily seed grinding capacity, knowing the oil yield of each class included in the seed structure, an investment cost of 412 U$S/Ton was estimated for oil's annual production capacity.

3.1.5 Dairy products

The sector is highly concentrated in a small number of companies, to the point that three of them process 50% of the country's milk. The technological level of such companies is high, whereas the remaining plants' streamlining calls for investments.

Productivity is higher in milk and yoghurt, requiring larger investments for cheese manufacturing. Improvements in such scenario are not restricted to equipment updating but also to optimising distribution (transportation technology). Another expected innovation relates to the larger size of plants, mainly for the production of powder milk and yoghurt, which require large investments in machinery and technology.

Investment costs resulted from surveys among the sector's major firms, and such costs were obtained for plants producing fluid milk, powder milk, cheese, yoghurt, marmalade, and other products, with a structure similar to the company's production mix.

The investment cost was estimated in 264 U$S/Ton of annual products' mix output capacity.

3.1.6 Textiles

Such activity is structured through various basic supplies: cotton, wool, and other textile fibres. The cotton textile activity accounts for 65% of textile production's gross value.

According to the generalised backwardness of technology, a lot has to be done in this sector to update the production technology.

It is the opinion of Centro de Investigaciones Textiles (Textile Research Centre) of the Instituto de Tecnología Industrial (Industrial Technology Institute) that the cotton sector's lag can be estimated at between 10 and 20 years, according to the stage considered. As for the wool sector, the washing stores have a 40-year lag, spinning, 10 to 20, and dry cleaning establishment, between 20 and 30 years.

The above mentioned excludes integrated cotton plants —accounting for 50% of the production— which are technologically more up to date.

On this basis, the measures to be taken include:

1. Rapid introduction of automated processes in the industry.
2. Use of up to 75 kW electric pumps in the vacuum dyeing system.
3. Introduction of last generation machines for fabric finishing.

4. On-line systems for control and use of CAD-CAM.

5. Quality assurance systems (ISO 9000) with a view to exports.

The above improvements do not cover the full range of needs and are mentioned just by way of example. The increase in installed capacity to cover production growth is geared towards integrated plants with world class technologies.

The investment costs for these new plants were obtained from Federación de Industrias Textiles (Textile Industries Federation), who provided extensive and documented information.

Based on investment costs in yarn and weave plants and the respective annual production, a mean investment cost was estimated of 2,300 U$S/Ton annual production capacity.

3.2 Energy intensity

According to the hypotheses developed, the energy intensities of these selected sectors exhibit significant differences between both scenarios, as illustrated in Table 72.

Table 72   Difference in energy intensity between scenarios (%)

Sector	2010	2020
Pulp and paper	9.0	23.7
Cement	10.6	29.4
Meat packing houses	17.1	42.0
Oil	17.4	30.4
Dairy	25.3	25.2
Textile	40.7	50.4

As mentioned in previous paragraphs, energy intensity evolution is based on the "state-of-the-art" development considered in the already mentioned UNIDO publications, and implies assuming substantial improvements in the selected sectors efficiency based on a growing proportion of the state-of-the-art technologies internationally available.

It can be seen that in all cases, substantial energy efficiency improvement is expected in the mitigation scenario compared to the baseline scenario, which is growing as a function of the technological backwardness noted in the different sectors. By way of summary, given that technological considerations have already been discussed, the previous figures are supported by aspects such as:

• In the paper industry, existing plants' production scale is quite below those evidenced by modern technologies. The growth of both domestic and international markets is expected to result in production scales with much higher performances than those obtained with present technologies.

• Although the cement industry's performances are closer to resemble international standards, it is to be hoped that technological evolution will imply growing outputs and an expanding proportion of state-of-the-art technology in the sector.

• The Argentine meat packing industry's energy efficiency average is extremely low as compared to international standards. Consequently, it is expected that in case actions oriented at GHG mitigation are implemented high performance technologies can be incorporated, with substantial energy efficiency increases.

- The oil industry is one of the branches where state-of-the-art technologies have been largely incorporated, i.e. about 50% of the present production capacity is based on such technologies, efficiency improvements presented in the study assumed that in the mitigation scenario, performances close to state-of-the-art technology could be reached for the whole sector.

- The dairy industry is significantly concentrated in very few companies equipped with highly efficient installations. However, the rest evidence a broad range of technologies and outputs with efficiencies well below the market's leading companies. The strong reduction expected in energy intensities based on the hypothesis of growing concentration —with substantial production scales increases— and the incorporation of state-of-the-art technology in a branch where international trade —especially in Latin America— is acquiring significant importance.

- Finally, the textile industry evidences the largest technological lags affecting the whole sector. Actions oriented at the rational use of energy find in this branch a very suitable arena, with almost spectacular results, tied however to internationally available technologies.

3.3 Methodology to assess mitigation costs

The process to calculate mitigation costs corresponding to the industrial sector involved many difficulties. The major problem to overcome was the limited reliable data on the investments required to gain future access to state-of-the-art technologies in the years taken as reference (2010; 2020). The lack of information on the monetary costs involved in the adoption of such technologies prevented us from using differential prices for state-of-the-art technology in each period and the present ones. Therefore, the values used are those of the most advanced present technologies. Thus, such scenario's higher mitigation effort, compared to the baseline scenario, was assumed to be reflected exclusively by a higher proportion of replacement of the oldest technology by the newest and this greater effort could be accounted for by the difference between the energy intensities existing in each of the scenarios.

To such end, the data provided for each sector's energy consumption and for each period were considered, including both components. On one hand, the value added (which is one for both scenarios as the socio-economic scenario is just one) and, on the other hand, Energy Intensity (much lower in the mitigation scenario than in the baseline). Such data are available for the reference years and the procedure is not problematic as long as the variables' assumed growth trajectory is linear.

Thus, the following equation was postulated:

$$VA_n * IE_n = \alpha \, Va_n * IE_{n+1} + (1-\alpha) \, VA_n * IE_{n-1} \qquad\qquad Eq. \, 1$$

where *VA* is the value added and *IE* the energy intensity.

In this equation, a given year's energy consumption (for each of the sectors) would result from an α proportion of energy consumption from state-of-the-art technology and an amount resulting from the use of existing equipment *(1-α)*, whose energy consumption is explained by the incidence of higher energy intensity. Thus, combining the use of existing (higher energy intensity), and "state-of-the-art" equipment (greater efficiency in terms of energy intensity), such period's actual energy consumption is obtained.

Such α proportion of the capital used with state-of-the-art technology is in turn made up by one part corresponding to the larger capacity required to cover the growing production assumed in the socio-economic scenario, and another part resulting from the size of old equipment replacement to be completed in each period. While the increase in production capacity is equally assumed for both scenarios (considering the dynamic efficiency premise used to build the baseline scenario) the same does not necessarily happen with the replacement investment. Bearing in mind that in the mitigation scenario a larger investment is made, it seems reasonable to think that the replacement rate (and, therefore, the corresponding investments) in the mitigation scenario shall be larger than in the baseline.

To calculate the investment required, a number of assumptions were made. First, it was postulated that the investment required for capacity expansion would be a direct function of the increase in sector value added between one period and the other. This, in turn, also implies that the physical relationship between produced physical volumes (in Tons) and their corresponding value would remain constant throughout the whole period under analysis and also that the use of installed capacity will not vary throughout the period[36].

Secondly, according to estimates from expert sources, it was considered that the capital stock existing in each economic sector, corresponded (approximately) to 15 to 20 fold the fixed gross annual investment, depending on the speed at which each sector would be retrofitting into capital-intensive. This (equal to about 5% to 6.67% a year equipment replacement or, from a different standpoint, considering that the equipment's average age is 15 or 20 years, according to the case) was compared to investment figures from the 1994 census, a process which served to confirm that such assumption was reasonable. To simplify the calculation, it was assumed that 15 years was the equipment's average useful life was.

Thirdly, it was postulated that the greatest mitigation effort made in this scenario compared to the baseline scenario, resulted from the need to incorporate new technologies to reach the lower energy intensities assumed for the mitigation scenario. This greater effort is accounted for by the difference between the α found for the mitigation scenario and the α found for the baseline scenario.

Each scenario's α value results from identifying the proportion related to state-of-the-art investment in Equation 1.

The evolution of investments was thus estimated, for each period and sector, always starting from the sector added value figures, i.e., assimilating the sector added value to the capital stock required to produce such added value, or, in other words, assuming a constant capital - product ratio.

As an additional step, the added value figures were converted to tons of product (as the 1994 Economic Census production figures in physical terms are available) and the tons to be produced with state-of-the-art technology were calculated so as to measure the investment required to produce those tons with such technology.

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[36] This in turn may imply two different situations. The use of installed capacity is either considered close to 100% (no idle capacity), or spite of the existence of idle capacity (unused plant capacity), same is of such nature that it can not be used should a production increase be required. Both effects (for the sake of the present analysis) are analogous as long as they imply that all additional production will result from plant expansions and not from a higher use of the existing capacity.

The transformation of figures to tons facilitates the cost allocation to the various installed capacities to be covered with the new technologies in each period and sector, while the information on monetary costs associated to new technologies' implementation is generally given for certain installed capacities, habitually measured in tons. In such sense, information was collected on investment costs per ton of product in the pertaining industrial sectors, and the equivalent annual cost was calculated for each sector and reference year (2010; 2020), for each of the selected discount rates (3%; 5%; 10% and 12%) and for a-15 year average useful life.

After finding the investment per ton for both scenarios, for each sector and period, operation and maintenance costs have to be added (both for the replaced and unreplaced part of capital) plus fuel expenses, in order to calculate total mitigation costs. In the case of operation and maintenance costs, a percentage was taken on the investment values. As for fuel expenditure, the structure of energy consumption by source was taken into account as well as the evolution expected in each source's price in the pertaining reference year, which resulted in the use of an average price per sector and year.

This procedure implies accepting two assumptions: on one hand, that capital is perfectly divisible in the case of the plant modules required for production. On the other hand (and unless prices are available for different types of technologies), it is also being assumed that the prices of the technologies used for both scenarios are equal. Such situation (although the existence of "no regret" situations is not ruled out) would lead to underestimating, at least partly, the actual incremental cost of implementing technologies in line with the mitigation scenario.

3.3.1 Results obtained

The analysis was carried out for two periods, 2010 and 2020, whose results are included in the following tables:

Table 73 CO_2 savings and costs, year 2010

Sector	Ton of CO2 Saved (Ton/Year)	Cost per Ton (US$/Ton) r=3%	Cost per Ton (US$/Ton) r=5%	Cost per Ton (US$/Ton) r=10%	Cost per Ton (US$/Ton) r=12%
Pulp and paper	389380	52.43	86.20	180.55	221.77
Cement	393494	2.96	15.06	48.84	63.61
Cold-storage plants	198746	747.91	883.93	1263.90	1429.92
Oils	563595	-83.91	-48.41	50.74	94.07
Dairy products	242103	214.17	272.19	434.26	505.07
Textiles	431058	-63.34	-40.83	22.05	49.52

Table 74 CO_2 savings and costs, year 2020

Sector	Ton of CO2 Saved (Ton/Year)	Cost per Ton (US$/Ton) r=3%	Cost per Ton (US$/Ton) r=5%	Cost per Ton (US$/Ton) r=10%	Cost per Ton (US$/Ton) r=12%
Pulp and paper	1593009	0.27	23.95	90.09	118.99
Cement	1481190	-39.03	-31.03	-8.68	1.08
Cold-storage plants	772893	588.80	705.10	1029.98	1171.93
Oils	1682624	2.13	24.58	87.31	114.72
Dairy products	443445	86.49	126.84	239.58	288.83
Textiles	778860	-92.26	-70.72	-10.56	15.73

It can be seen that both textile and oil present "win-win" options in the medium term, while in the long-term textile and cement present negative costs for low discount rates.

The ranking for each of the periods is presented in Table 75 and Table 76. In the medium term, the most attractive branches as regards costs and volumes saved are oils, textile, and cement. In the long term, the textile branch still remains attractive, followed by the energy-intensive paste and paper.

Table 75   Ranking by industrial branch, year 2010

Sector	r=3%	r=5%	r=10%	r=12%
Pulp and paper	4	4	4	4
Cement	3	3	2	2
Cold-storage plants	6	6	6	6
Oils	1	1	3	3
Dairy products	5	5	5	5
Textiles	2	2	1	1

Table 76   Ranking by industrial branch, year 2020

Sector	r=3%	r=5%	r=10%	r=12%
Pulp and paper	3	3	4	4
Cement	2	2	2	1
Cold-storage plants	6	6	6	6
Oils	4	4	3	3
Dairy products	5	5	5	5
Textiles	1	1	1	21

The following figures include the cost curve calculation for 5% and 10% rates.

Figure 87   Mitigation cost curve, year 2010
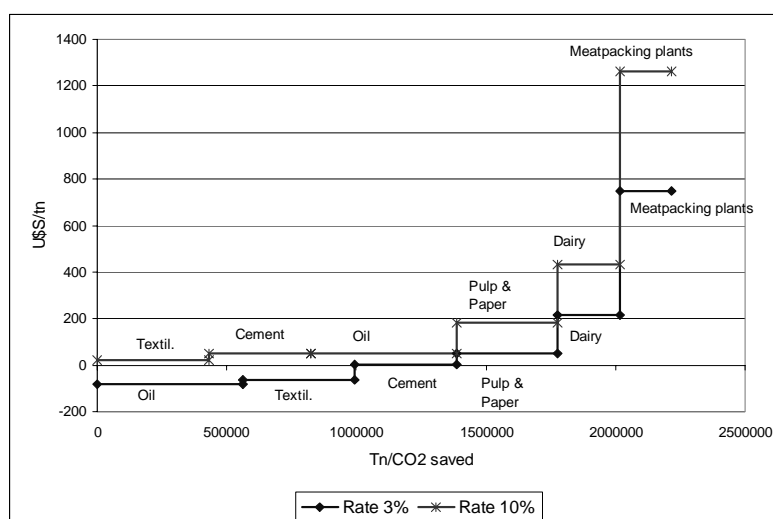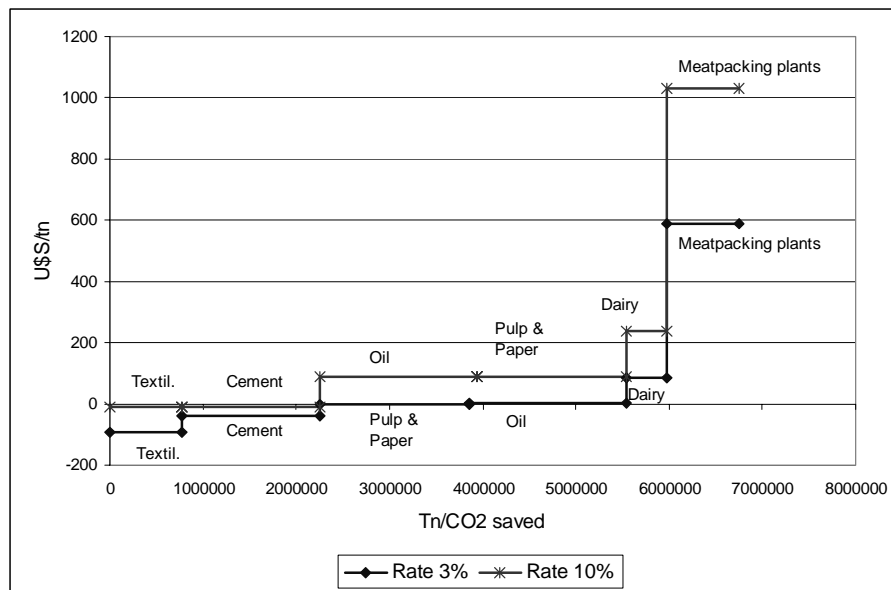
Figure 88   Mitigation cost curve, year 2020

4 Cogeneration

4.1   Energy-productive processes

Cogeneration is one of the GHG mitigation options adopted for the industrial sector. This technology offers the possibility of jointly producing electricity and heat not with the aim of decreasing the useful energy required but rather, of having a lower net energy demand for the same amount of useful energy.

Such definition could lead to assume the existence of a large potential in the national industry, as practically all its branches use heat and/or electricity, and the lower demand of energy to obtain such heat and electricity should stimulate the application of this technology.

However, on evaluating costs, regulatory and technical signals, electricity and gas tariffs for the industry, etc., such potential has decreased. In such sense, and in order to provide more realistic and accurate figures, certain assumptions have been made that will be repeated in order to make the following analysis clear.

Among the hypotheses used to define the cogeneration potential are the following:

6.   considering the universe of electricity self-producing industrial plants, i.e. which for some reason (safety and quality of supply, prices, etc.) have made an investment in some type of equipment for that end;

7.   within the above-mentioned universe, industrial branches using steam for process were considered. It was thus determined that: within the food branch, certain meat packing houses, oil industries and dairy plants comply with both conditions -self-producers-steam users. This is also the case of the paper industry within the energy-intensive sector.

With the goal of assessing the cost associated to the selected mitigation option, the layout of industrial cogeneration processes proposed for the above mentioned branches shall be presented first in a schematic way.

Figure 89 shows an electricity generator driven by a gas turbine; the hot exhaust gases are passed through a recovery boiler to generate steam.

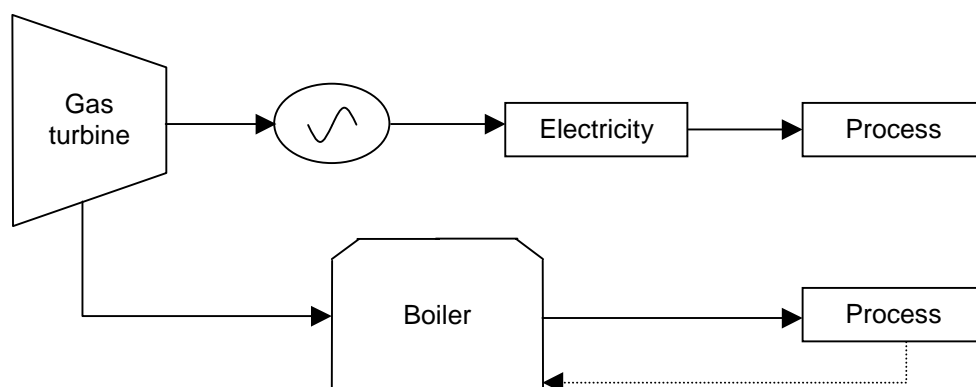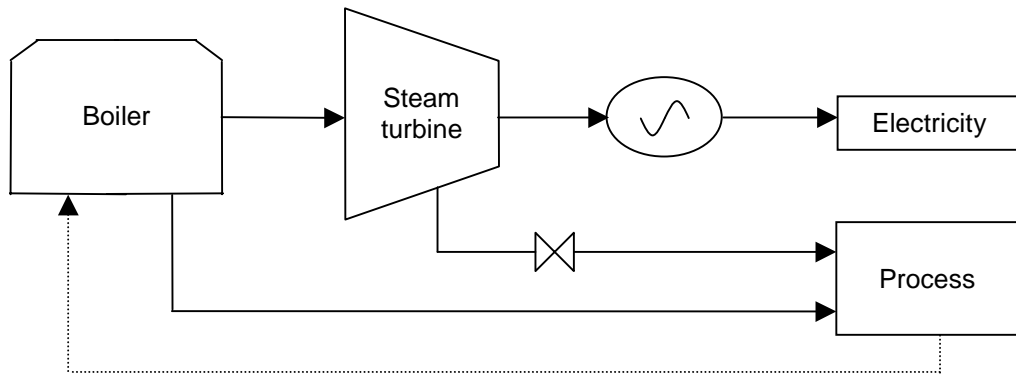*Figure 89   Cogeneration with gas turbine*

Figure 90 depicts an electricity generator with a back-pressure steam boiler-turbine system using its exhaust steam for industrial processes, besides using the surplus heat generated by the boiler for mechanical uses and process heat .

Figure 90   Cogeneration with steam turbine

Several energy-producing schemes of a general nature are presented for the above mentioned potentially cogenerating branches. The goal is simply to highlight heat and/or electricity using processes in which "closings" of cycle could be applied to cogenerate. Such closings would permit significant improvement in efficiency, energy saving and gases mitigation.

No numeric values or percentages are provided, due to the general nature of the above-mentioned scheme, as it is assumed that each plant has a different layout according to the production technology used.

Figure 91 shows the energy structure of a generic plant in the agrofood industry, as this branch includes potential cogenerators (i.e. meat packing, oil and dairy). It is interesting to consider the energy use mechanisms in each of the phases of such structure, in order to identify potential savings in points where avoidable losses or leaks exist, or where process can be improved through cogeneration.

Figure 92 illustrates the steam and electricity demands in meat packing or beef industry, i.e. extraction and grinding, mixing, packing and delivery, and preservation. Natural gas is an input in both cases.

Figure 91   Agrofood industry. Energy structure of a food-producing plant
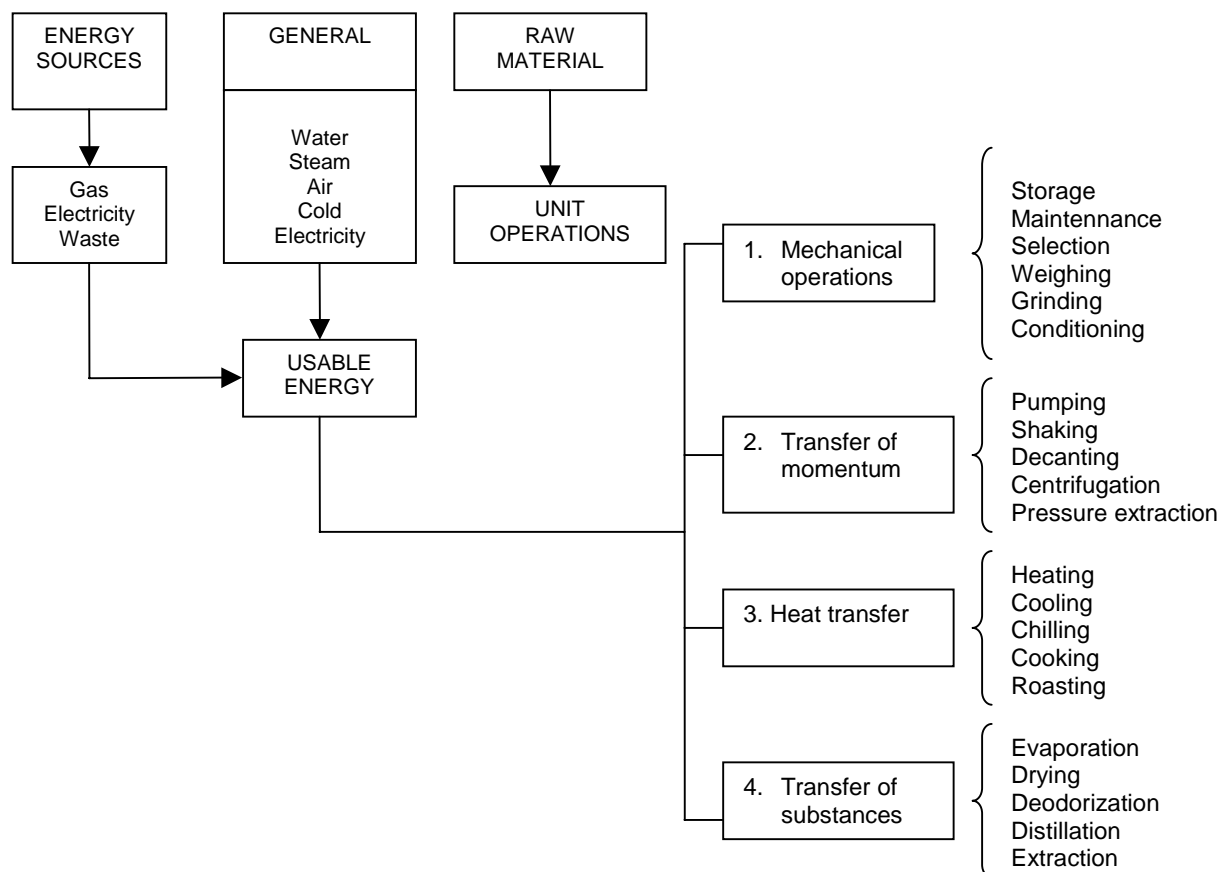
Source: IDAE

Figure 92   Beef industry - Energy diagram
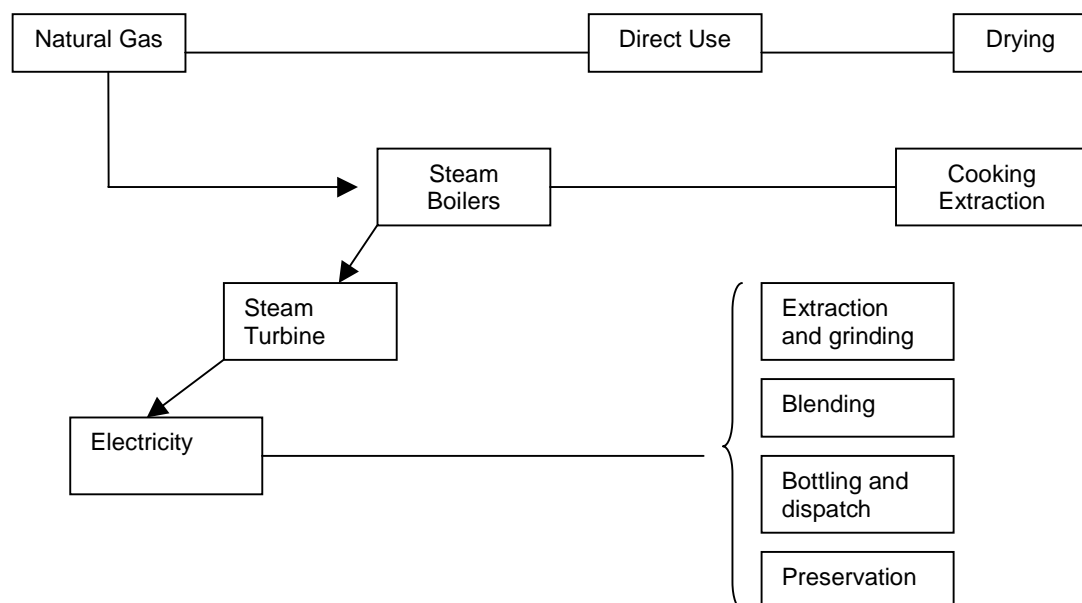
Source: Energy Saving Techniques for the Food Industry Noyes Data Corporation 1977. New Jersey.

240

Figure 93 illustrates in a general way the principal operations common to all end products in the dairy industry, namely cleaning and cold storage. Afterwards, processes are divided into those that demand heat of any sort (dry or wet in exchangers), as for example to produce pasteurised and sterilised milks and yoghurts, and those in which water content is key for the production of concentrated and powder milk.

Figure 93   Milk treatment processes diagram
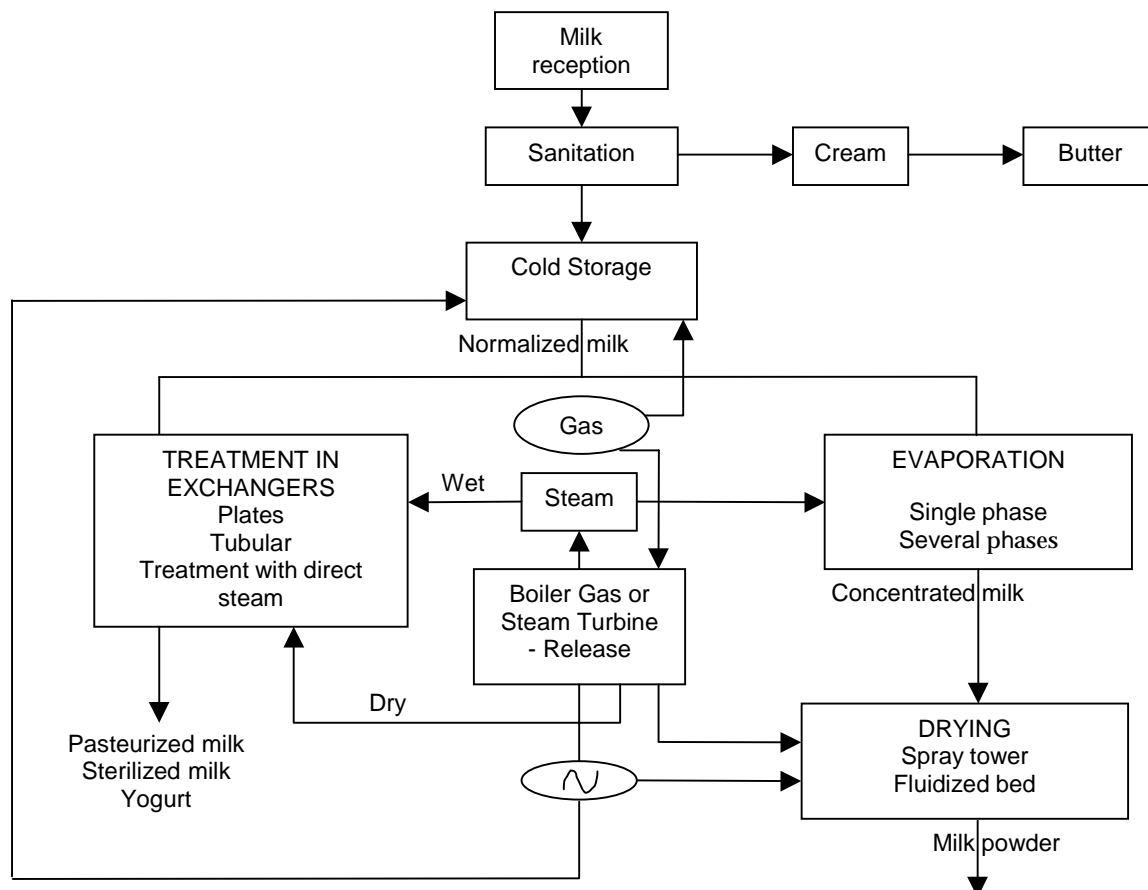
Source: IDAE

The most representative equipment used in processes are: pasteurisers and sterilizers —heavy users of dry or wet heat—; steam-using concentrators; dry heat-using dryers (possibly of electric origin); hot water-using washing equipment (steam); and electricity powered centrifugation and refrigeration equipment. It could then be concluded, as anticipated, that for this industry the combination and closing of processes using electricity-dry heat and steam is possible and convenient.

In the oil industry, the most relevant processes seed preparation (drying, grinding, husking, etc.) where waste could be used for energy production, and oil extraction and refining (see Figure 94). In both processes electricity and steam demands combine in different proportions: in grinding, only electricity plays a role; in husking, seed preparation and extraction, steam and electricity play similar roles, and in refining, both electricity and thermal energy participate but in different proportions.

Figure 94   Agricultural food industry. crude and refined oil processing diagram.
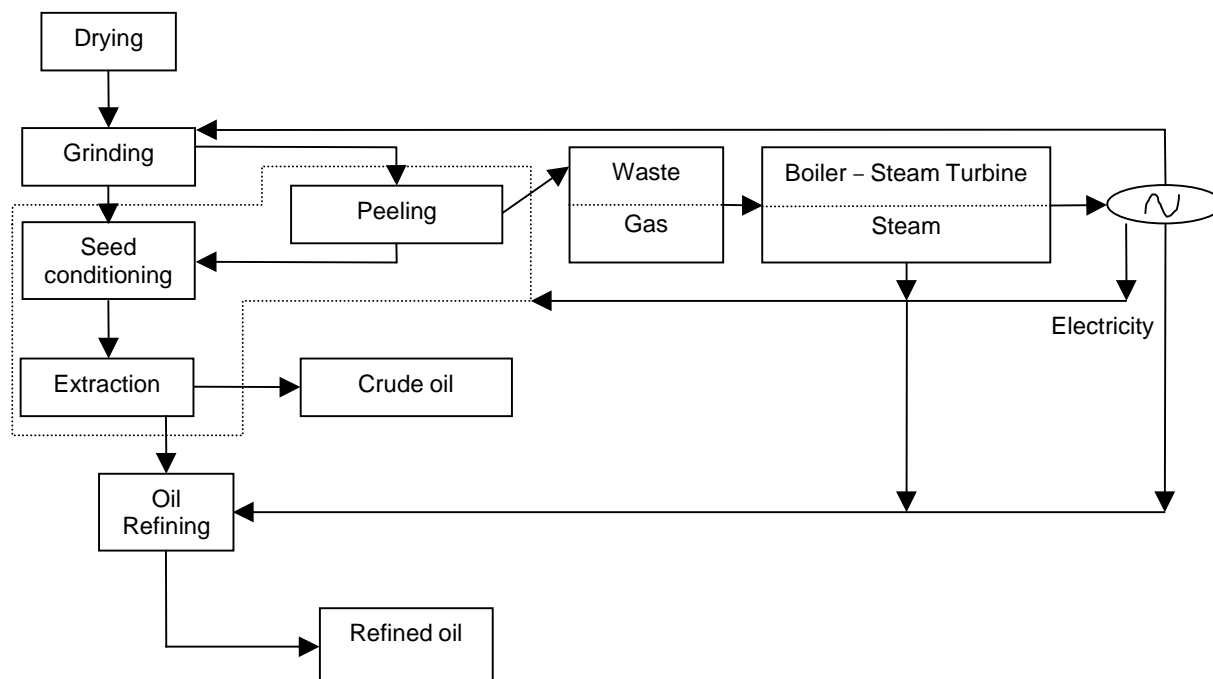
Source: IDAE

In the paper industry, the elaboration of cellulose pulp (mechanical and chemical) and paper are considered. Figure 95 presents a generic diagram of both production process illustrating the electricity and steam requirements, as well as the cogeneration possibilities. Non-usable forest waste would be used in the TS boiler.

4.2   Cost calculation: methodological approach and basic hypotheses

It has already been said that the sectors selected to assess the potential and costs associated to cogeneration are: pulp and paper, oil, meat packing, and dairy; for the former two, natural gas and biomass are considered, whereas for meat packing and dairy only natural gas is contemplated. Additionally, the theoretical potential for natural gas and biomass was analysed in the rest of the industries —energy and non-energy intensive—.

In order to compare, within a wide range of possibilities, the costs associated to cogeneration, several hypotheses and alternatives were developed: supply agreement with a public service generator, direct purchase in the retail market or maintain present self-production. Given that the hypothesis developed when defining the scenarios assumed that cogeneration would displace the existing Self-production, the latter alternative was adopted in order to estimate mitigation's incremental costs. It should be pointed out that this alternative is the most favourable from the cogeneration standpoint, i.e. the "difference project" presents the lower equivalent annual cost.

242

Figure 95   Paper manufacture. Production / energy process diagram
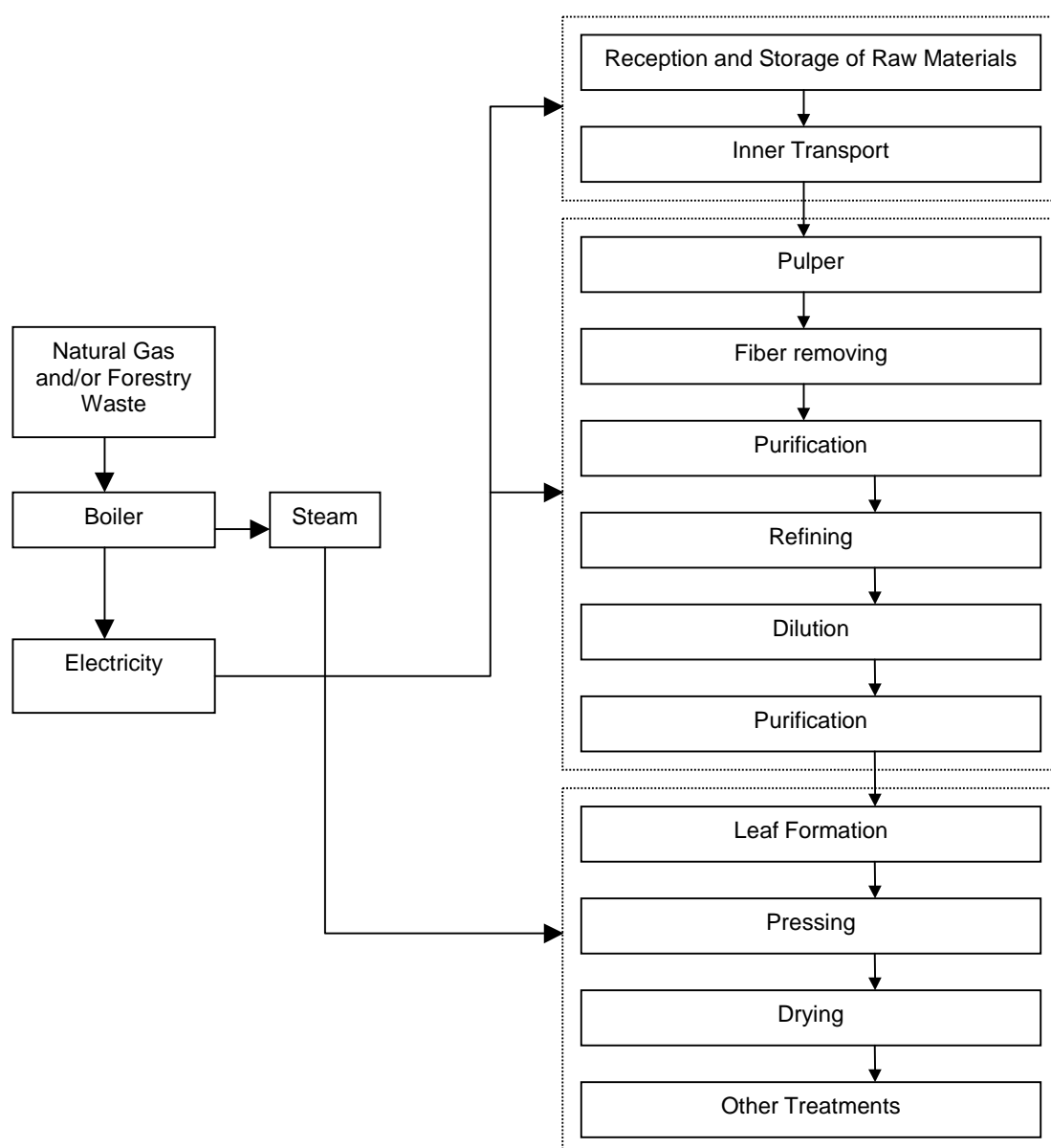
Source: IDAE

The assessment methodology used was discounted cash flows, on the basis of the cost-effectiveness principle and applying the annuities criteria, i.e. the equivalent annual cost was calculated. The calculation was made for two periods: medium term —2010—, and long term —2020—.

The following tables summarise the values assumed for the relevant variables under the hypothesis that the cogeneration alternative implies closing the cycle on the basis of existing equipment, i.e. "incremental" investments for the so-called medium term —2010— and total investments for the long term —2020—, for the natural gas-fuelled alternatives.

Table 77   Values assumed for the cogeneration alternative, year 2010

Branch	Investments in cogeneration (US$/kW)	Operation and maintenance costs (US$/MWh)	Fuel cost (US$/MWh)	Power service cost (US$/MWh)
Paper	455	8.0	5.2	9.26
Oil	455	8.0	5.2	9.26
Cold storage	585	8.0	5.2	9.26
Dairy products	900	8.0	5.2	9.26
Rest energy int.	455	8.0	5.2	9.26
Rest non-energy int.	585	8.0	5.2	9.26

Table 78   Values assumed for the cogeneration alternative, year 2020

Branch	Investments in cogeneration (US$/kW)	Operation and maintenance costs (US$/MWh)	Fuel cost (US$/MWh)	Power service cost (US$/MWh)
Paper	700	7.6	5.8	8.33
Oil	700	7.6	5.8	8.33
Cold storage	900	7.6	5.8	8.33
Dairy products	900	7.6	5.8	8.33
Rest energy Int.	700	7.6	5.8	8.33
Rest non-energy int.	900	7.6	5.8	8.33

The calculation of equivalent annual costs for each of the alternatives was made for 3, 10, and 15% discount rates.

4.3.   Results obtained

The costs per ton of CO_2 saved for each of the sectors analysed and for both periods —in the case of natural gas— appear in the following tables.

Table 79   Cost of CO_2 saved for natural gas, year 2010

Branch	Savings CO_2 (Ton/year)	Rate 3%	Rate 10%	Rate 15%
Paper	158250	-77.28	-69.88	-63.74
Cold-storage plants	5861	-73.57	-64.04	-56.15
Oil	41028	-77.28	-69.88	-63.74
Dairy products	2931	-64.56	-49.91	-37.77
Textiles	2721	-62.59	-46.81	-33.73
Total	210791	-76.81	-69.14	-62.78

Table 80   Cost of CO_2 saved for natural gas, year 2020

Branch	Savings CO_2 (Ton/year)	Rate 3%	Rate 10%	Rate 15%
Paper	58611	-81.69	-70.30	-60.85
Cold-storage Plants	5861	-75.98	-61.33	-49.18
Oil	32236	-81.69	-70.30	-60.85
Dairy products	8792	-75.98	-61.33	-49.18
Textiles	2721	-62.59	-46.81	-33.73
Total	108221	-80.44	-68.49	-58.59

Figure 96 and Figure 97 illustrate the mitigation cost curves for the selected sectors, both periods and 3% and 10% rates.

Figure 96   Mitigation cost curve, year 2010
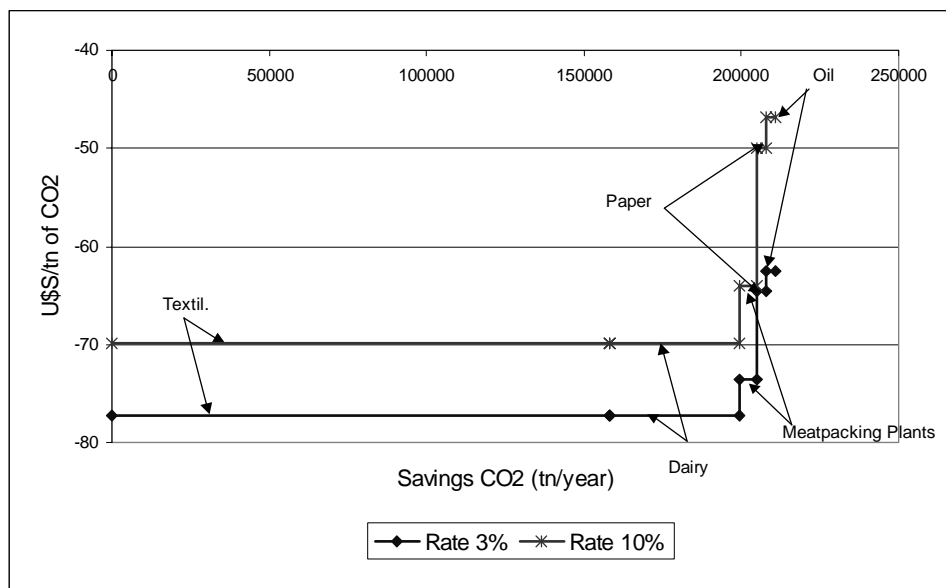

Figure 97   Mitigation cost curve, year 2020
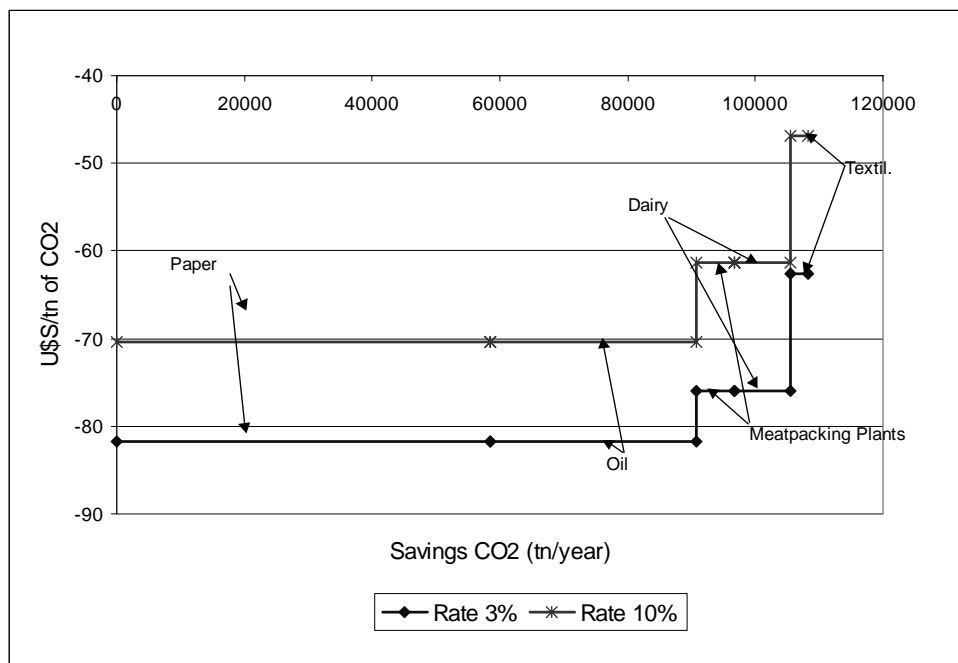
As for biomass, same can potentially be used in two branches: paper and oil. In this case, an increase exists in investment costs, as well as in operation and maintenance costs, offset by the lower fuel costs. Results for the case of biomass are summarised below:

Table 81   Cost of CO₂ saved for biomass

Period and Branch	Savings CO₂ (Ton/yr.)	Rate 3%	Rate 10%	Rate 15%
2010				
Paper	143016	-45.69	-38.24	-32.06
Oil	59179	-46.02	-38.77	-32.76
2020				
Paper	54247	-53.39	-45.94	-39.77
Oil	39453	-53.73	-46.48	-40.46

Figure 98   Mitigation cost curve, year 2010
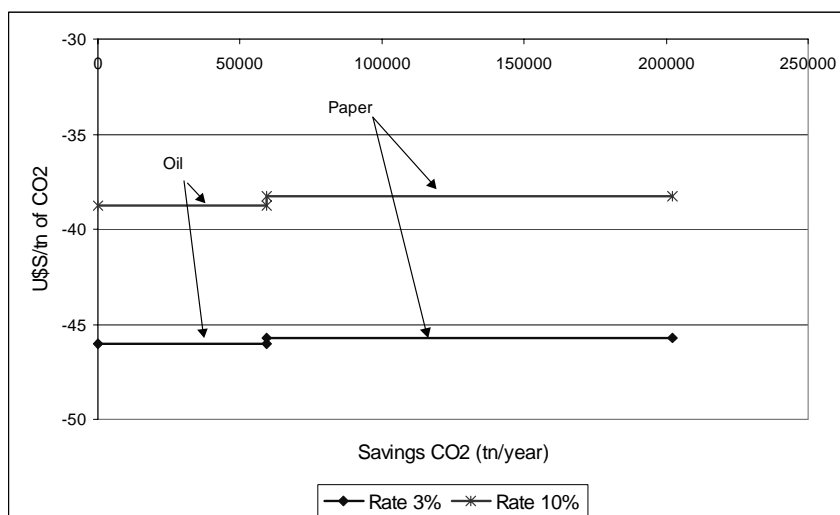
Figure 99   Mitigation cost curve, year 2020
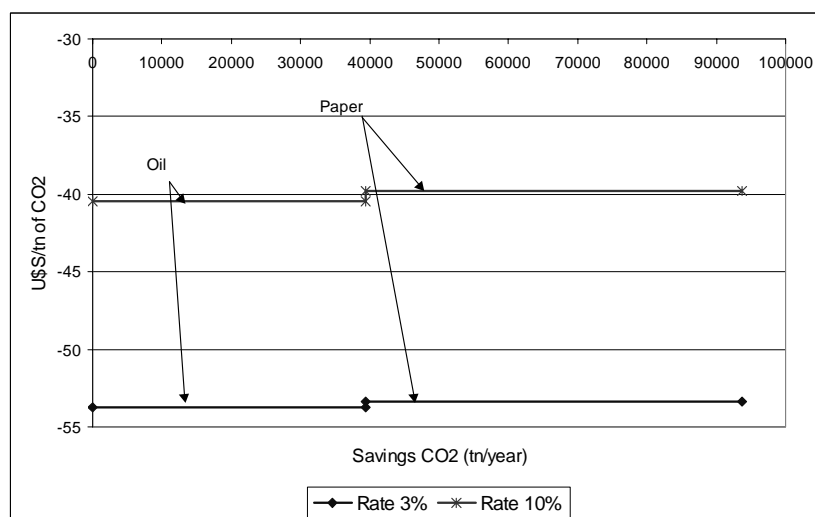
Additionally, more aggregate analyses were developed for both rests —energy and non-energy intensive—. The costs per ton of CO2 saved did not substantially differ from those estimated for the sectors analysed in greater detail.

As noted, cogeneration alternatives are the most cost-effective as they yield negative costs per Ton of CO2, thus resulting in "win-win" projects, i.e. projects that are justified even

246

without having GHG emissions abatement as a goal. The question that may then arise is this: being convenient, why don't such projects materialise? The answer results from different dimensions.

On one hand, the investments in cogeneration compete with other investment possibilities in production itself which, eventually, may appear more attractive. When resources are limited, decisions are probably based on the profitability rate and not necessarily on a positive Net Present Value at a certain discount rate.

The legal and regulatory framework may become a barrier to the development of cogeneration. Given that alternatives are particularly interesting if possibilities exist to supply energy to the grid, very complex conditions required to comply with the public Service supplier function may discourage Cogeneration and prevent or delay the development of such alternative.

The role of energy in total production costs is another important decision making element. The more intensive energy costs are, the more possibilities for actions on rational use to be a priority in industries' investments. In many of the branches, energy plays a key role in production, but its impact on costs is not key and therefore loses priority when it comes to investment decisions.

An element related to the above, in part, refers to the price of energy products: the volatility of some —e.g. oil and petroleum products—, the downward trend of others —electricity, for instance— and the medium and long term uncertainties of a market that emits confusing signals do not act to promote actions aimed at decreasing energy consumption.

On the other hand, the players' own rationale: short-term view, rapid return of investment, risk reduction are no suitable scenario for investments which, albeit financially sound, may imply relatively long return of investment periods, higher risks and relatively low profitability rates.

Finally, the large industries with high negotiation capacity because of their relevance as energy users, may obtain extremely advantageous contractual conditions for electricity and natural gas supply, this being an additional element to discourage rational use of energy actions.

The previous considerations lead to the conclusion that the economic magnitudes and values found imply that substantial technical and economic potential exists for Cogeneration, although same cannot be considered a market potential.

For such potential to materialise, certain barriers should disappear, creating incentives and assessing mechanisms to transform such technical-economic optimum into a market optimum. Such mitigation options' "implementation" actions involve additional costs that have not yet been included in the calculation presented in this chapter.

5 Electricity

5.1 The electricity industry. Introduction

As indicated in Chapter 7, mitigation alternatives in the electricity industry focus on the generation segment, assuming the higher penetration of hydropower, nuclear energy and wind energy substituting for natural gas.

Besides a lower electricity requirement resulting from the rational use of energy actions considered by consumption sectors, the mitigation scenario illustrates a generation structure with a higher participation of non-emitting sources based on already identified and assessed projects that offer the best competitivity vis-à-vis the alternatives analysed in the baseline scenario.

In such sense, hydroelectric equipment, atomic power stations and wind turbines have been considered replacing natural gas-fired thermal equipment.

5.2 Methodological approach and basic hypothesis

The assessment methodology used was discounted cash flows, on the basis of the cost-effectiveness principle and applying the annuities criteria, i.e. the equivalent annual cost was calculated, similar to the one used for the rest of the sectors under analysis.

Table 82 summarises basic data for the projects under analysis, assumed values for their relevant variables.

Table 82   Data and assumptions for projects under analysis

Project	Unit Investment (US$/kW)	Operation and maintenance costs (US$/MWh)	Fuel costs (US$/MWh)	Installed power (MW)	Useful life (Years)
Corpus	993	0.413		2880	50
Garabí	720	0.658		750	50
Las Pavas	2045	1.081		88	50
Arrazayal	1505	0.977		93	50
Cambarí	1961	0.868		102	50
Paraná Medio	1357	0.265		3000	50
Nuclear Station	1400	0.986	8.0	740	35
Wind charger	1200	18.30		70	20
TG Combined Cycle	500	0.580	10.83(*)	700	20

(*) Under the hypothesis of 1.8U$S/10^6 BTU

The equivalent annual costs for each of the alternatives were calculated for 3, 7, 10, and 15% discount rates.

5.3 Results obtained

The costs per Ton of CO_2 saved for each of the non-emitting projects, assuming a natural gas price of 1.8 U$S/10^6 BTU, and for different discount rates are shown in Table 83.

It can be seen that for low discount rates (3%), options with negative costs appear —in all cases, hydroelectric power stations—, for rates over 7% no "win-win" alternatives exist as all present positive costs, which shows the relevance of discount rates to define "win-win" options.

Table 83   Cost of CO₂ saved for non-emitting projects

Project	Savings CO$_2$ (Ton/yr.)	Rate 3%	Rate 7%	Rate 10%	Rate 15%
Corpus	6468149	-25.11	-8.67	7.9	42.87
Garabí	1123415	-21.78	-1.61	19.3	64.78
Las Pavas	125959	17.42	78.91	140.5	271.14
Arrazayal	146384	-3.18	36.02	75.5	159.6
Cambarí	180427	2.70	48.79	95.2	193.70
Paraná Medio	6331978	-16.60	17.03	56.3	155.15
Nuclear station	1788614	7.63	26.01	45.0	86.89
Wind charger	62625	143.80	180.30	211.2	267.94

According to previous results, the order to build the mitigation costs' curve would be:

Table 84   Ranking for the mitigation cost curves

Project	Rate 3%	Rate 7%	Rate 10%	Rate 15%
Corpus	1	1	1	1
Garabí	2	2	2	2
Paraná Medio	3	3	4	4
Arrazayal	4	5	5	5
Cambarí	5	6	6	6
Nuclear Station	6	4	3	3
Las Pavas	7	7	7	7
Wind charger	8	8	8	8

When the order is defined according to different discount rates, a second effect appears, on top of the disappearance of "win-win" options, i.e. a change in order between options, e.g. the nuclear power station that ranks sixth for the 3% rate, moves to the third place at rates above 10%, displacing three hydroelectric power stations. Such second effect is associated to the cash flow profile of the different alternatives and clearly illustrates how high discount rates "discriminate" projects with high investment costs and low operational and maintenance costs whereas they favour those that imply lower investment cost and higher operational costs. On the other hand, it is noted that the Windmill is far from being competitive vis-à-vis "conventional" technologies such as hydroelectricity, although it could well have a role in supply to isolated dwellers or systems for which centralised systems are not competitive or cannot be accessed for other types of reasons.

Figure 100 shows the mitigation costs curves for the selected sectors, both periods and 5% and 10% rates.

6   Final considerations

6.1   General

From the analysis of the results presented, with all the considerations which are appropriate to them and which we shall expound later on, it is concluded that the actions related to the supply of electricity —substitution of thermal generation with non-emitting technologies and cogeneration within the industrial sector— appear as the most interesting or most cost-effective options.

Figure 100   Mitigation cost curve
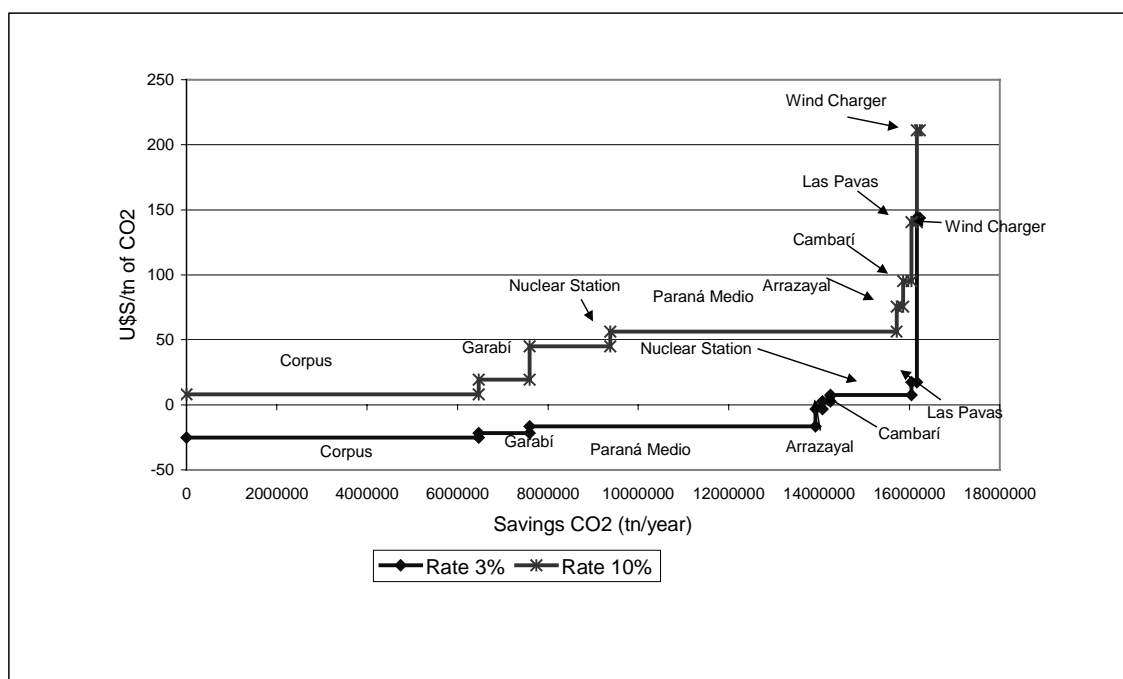
As a matter of fact, it is in these cases where negative mitigation costs abound, although it is true that such magnitudes and signs depend on the discount rates used. For 10% rates, negative costs only remain for all sectors in the case of cogeneration, while in the case of public electricity service all hydro alternatives register positive costs.

As for consumption sectors, the industrial sector branches studied show options which prove less costly than those of the transport sector, although volumes to reduce could be much higher in the latter case than in the former. In the industrial sector, we notice several branches with negative costs —for low discount rates—, while averages register values close to sixty dollars per ton of CO2. The transport sector offers some interesting options, mainly those related to substitution among sources and particularly with CNG. However, technical improvement and substitution among sources —options with effects in the longer run and other significant benefits at local level— have in general very high costs, with values per ton of CO2 which are quite above ranges which are reasonable for project implementation.

6.2   On the methodological approaches and assumptions

The calculation of mitigation costs has multiple implications and is influenced by a series of elements, such as the following:

The way in which the base scenario is determined: A base scenario which extrapolates the current situation keeping the productive efficiencies of the different supply and energy-consumption sectors frozen will overestimate the existing mitigation potential and underestimate the costs associated to such mitigation actions. In other words, a base scenario which does not incorporate technological innovation as a characteristic market process will allow the easy identification within the alternative or mitigation

scenario of highly cost-efficient reduction options, even with negative costs. A base scenario so determined would not be realistic and could lead to the raising of mitigation options which are assumed associated to a specific policy in that sense, and which would nevertheless take place due to the very action of the market. That is to say, they would appear at the base scenario even when no specific policies were raised.

Some methodological documents make reference to base scenarios of minimum cost or efficiency. In this case, it is assumed that a minimum cost scenario is an economically efficient scenario and that all mitigation options will have —by definition— a positive cost[37]. Actually, the following doubts should be raised: from which viewpoint a scenario is deemed economically efficient? Which is the underlying mentality? At which discount rate were the efficiency scenario costs calculated?

The results of our study show that the electricity generation equipment at the base scenario —in accordance with the decisions taken by the de-centralised agents— is an economically efficient scenario. Decisions are taken trying to minimise generation costs, guaranteeing a minimum profit expected by the agents on the basis of a combined-cycle thermal unit fed with natural gas. The raising of alternative scenarios on the basis of a different mentality and with a viewpoint and mentality which tolerates lower profit rates allows to pinpoint mitigation options at negative costs (hydroelectric stations) which provide higher useful life, lower emission, other additional benefits, etc. but which would never be chosen by the de-centralised agents on the basis of a mentality which implies the following: minimising investment, maximising returns, minimising risks and tying up resources for as little time as possible. How does one incorporate to mitigation costs the different mentality of the decision-maker and the different viewpoint which feeds both scenarios?

This last aspect justifies bringing forward an additional question: can both scenarios be compared? If policy goals differ, if objective functions associated to both scenarios include different priorities, can the economic costs of projects associated to both scenarios be compared through the use of price systems which respond to different wellbeing goals? This question would call for in-depth analysis. At a first glance, it would seem that the conceptual and methodological approaches which are being used do not consider the impacts which the scenarios will have on the price system nor in which way mitigation costs are internalising such changes.

Another relevant aspect related to mitigation costs is associated to the fact that the estimations of the costs associated to different measures only include direct costs, while actions evaluated should be considered at a merely potential level, and require that policies which allow to transform what is potential into something possible or truly achievable be made explicit and put into practice.

We know that a global or sectoral scenario which pinpoints emission-reduction options may be carried out at technical potential (all technically-possible alternatives), economic (all technically-possible alternatives which prove cost-effective), and market (all technically-possible alternatives which could be implemented on the basis of certain market conditions) levels. The estimations carried out in the present study, as well as the costs calculated, place the alternatives pinpointed between the first and the second category, that is, potential in a technical sense and possible under certain economic conditions. They could only become market alternatives if certain conditions

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[37]   UCCEE, Mitigation and Adaptation Cost Assessment: Concepts, Methods and Appropiate Use, IPCC Discussion Paper, June 1997, page 46

and devices were provided which would imply the evaluation of existing barriers for their implementation and the calculation of the additional costs which their conversion into market alternatives would imply.

The barriers pinpointed include institutional obstacles, information requirements, regulations, agent mentality and market distortion barriers.

The development of specific policies presupposes the evaluation of the necessary incentives to make mitigation projects viable (including specific financing, for example), implementation costs —including transaction and specific-program costs—, new regulatory measures and their collateral effects, financing costs and options.

Implementation costs are not a minor issue, and are related to issues previously expounded. When raising the implementation cost issue, certain papers[38] make reference to the notion that national strategies should be based on costs calculated at the level of the economy as a whole (accounting prices), including external aspects of environmental impacts and other significant social impacts. These costs will differ from the private costs faced by consumers or investors. The doubt on the possibility of comparing both scenarios expounded on the basis of an accounting price system responding to different goal functions was raised precisely with respect to this issue.

Moreover, implementation costs will include the need to make mitigation actions attractive to the decision-taking agents. These actions will imply certain policies related to subsidies, rates, soft loans, establishment of standards and regulations and even the direct implementation of projects.

These implementation actions involve additional costs which in general are not included in the mitigation cost curves estimated at project level. In other words, the estimated mitigation costs underestimate the true costs of the mitigation actions by not including the additional costs of the policy devices and actions to convert such actions from "desirable" into "possible or effective" ones.

Finally, we have the issues associated to the macroeconomic approach to costs: the existing interrelations between the different economic sectors —direct and indirect ones— and the effects associated to the modification of policies responding , for example, to mitigation scenarios.

The establishment of taxes, the implementation of subsidies, the reorientation of sectoral investment through different methods involve the appearance of impacts on different economic agents which will not be incorporated to "direct" mitigation costs.

A macroeconomic analysis would result necessary to estimate true costs, incorporating all direct and indirect effects. Nevertheless, it is true that a macroeconomic analysis poses challenges and additional problems.

The estimation of the effects could be carried out through the comparison of both wellbeing states[39] —the well being of society assuming that the actions are not implemented and the wellbeing of society assuming that they are—, which would require the following:

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[38] UCCEE, Chapter 8 – Implementations Aspects, op. cit., page 126
[39] Hourcade and Haites, Macroeconomic Cost Assessment , in UCCEE op. cit., page 87

1. A measurement of social wellbeing (Social WellBeing Function)
2. Assumptions on what takes place if the actions are not implemented and on how these actions would be implemented
3. The use of a macroeconomic model which allows to measure changes.

The measurement of the wellbeing of a society is not a simple task, and poses two main difficulties, namely:

1. Wellbeing improvement is related to income distribution and its measurement and impact on wellbeing will depend on the receiver of an income improvement. The poor attribute more value to an additional dollar than the rich do.
2. Individual wellbeing functions cannot be added, for doing it would imply ethical and political judgements and paying consideration to the functions of different individuals. The mere sum of individual wellbeing functions —if they could be estimated and calculated— would imply accepting the present income distribution as a good one.

The estimation of macroeconomic mitigation costs may only be carried out when it is possible to compare the situation with and without a mitigation policy. The results of such comparison will depend on the hypotheses made with respect to how the socio-economic system is working as regards its global efficiency and on whether the comparison between both scenarios must be made assuming the same efficiency level.

Additional considerations must be made on the different types of models which could be used for the analysis and comparison of the different situations, as well as the special consideration that different macroeconomic models may reach quite different results and estimations, which calls for a very careful understanding and use of such results.

The truth is that the estimations included in the present chapter have not incorporated the macroeconomic analysis nor the impacts on variables such as income distribution, employment, fiscal budget or GDP growth.

It may be thus concluded that the costs which have been included in this study as example represent a very preliminary approach, and it may be asserted that they underestimate real mitigation costs, since they do not include all aspects which should be taken into consideration.

Comments on the implementation of mitigation actions in Argentina

1.1 Introduction

As previously stated the GHG emission savings shown in Chapter VII should be considered as the potential impact of implementing a climate change mitigation policy in Argentina. This means that results estimate GHG emission abatement that could be achieved if "effective mechanisms" were developed to modify the expected behaviour of both social and economic agents in terms of their technological choice for energy consumption and supply.

Selecting the most effective mechanisms for policy implementation is not an easy task. In the first place, the type of mechanisms that can be used is highly dependent on the regulation and the institutional arrangement of the economy and particularly of the energy system. These characteristics define, in fact, the limits for governmental intervention on the system. In the second place, effectiveness is also related to the actual costs of mitigation measures, not only in monetary terms, but very especially to the magnitude and distribution of the different impacts such mitigation actions are likely to bring about.

Regarding regulations and even admitting that the rules in force can be changed to meet the best interest of society, the main features of the prevailing system can not be ignored. Particularly, considering that the true possibilities of amending the regulations depend on the relative power of the different agents within the system.

The economy and energy system restructuring carried out in the early 90´s in Argentina, which also included a thorough reforming of the State and its roles, was oriented to setting up free markets, expecting that competition will fix prices and also allocate resources in the economic system.

Within this context, the implementation of any policy, particularly a climate change mitigation policy as in this case, requires specific analysis that given its extent and complexity is well beyond the scope of the present project. Only in the specific case of the electricity power industry and within the framework of a project complementing this one, was a specific analysis carried out on the relevance of resorting to different mechanisms used in other countries to promote efficient use of electricity and new sources to generate electricity.

The main outcomes of this complementary project are presented in a separate report under the title "Implication of Electric Power Sector Restructuring on Climate Change Mitigation". The sole aim of this Chapter is to comment on the opportunities and obstacles that must currently be overcome when implementing mitigation policies. Thus, the scope of this chapter is somewhat more comprehensive than that of the complementary project as it comprises all energy sources, even though it does a less in-depth analysis.

The promotion of higher energy efficiency in end-use sectors and in energy supply is reviewed separately in the following sections. In both cases, a brief description of the present situation is made, regarding both the policies currently in force and the limitations exhibited by market forces to improve energy efficiency, and the obstacles to implement the mitigation actions

considered in this study are also commented. Finally, the opportunities and barriers to non-emitting sources for power generation are reviewed.

2 Energy efficiency at end-use level

2.1 Official policies

The restructuring was, as already stated, oriented to reinforce the free functioning of all goods markets in the country using international prices as reference prices, in the hope that imports would become an unlimited supply option for the domestic market and an alternative to local production. Even though this proved to be a most effective mechanism to align domestic prices for most tradable goods, although at the expense of a significant imbalance in the balance of trade, it did not produce the same effect in all energy markets.

In the first place, the supply of energy products distributed by grids, such as electricity and natural gas, can not move quickly from domestic production to imports. On the contrary, the economic feasibility of imports projects depends on the costs of the infrastructure required to carry out said imports and since major investments are the rule rather than the exception, they restrict the possibility of resorting to imports as a means of contingent supply to align domestic prices.

Even in the case of petroleum products, often regarded as more suitable for this kind of price regulation mechanism, there have been serious gaps between domestic and international prices. The oligopoly characteristic of oil refining in the country is reproduced in the retail marketing of these products, especially in motor fuels. The lack of independent retail stores (not exclusively tied to a petroleum products local supplier) places imports under the control of local suppliers, thereby eliminating them as a competitive option.

These difficulties became more clearly evident when petroleum product domestic prices did not follow the drop in crude oil international price and when local oil companies tried to offset the economic loss derived from this situation by keeping domestic prices of petroleum products high. Even though the Energy Secretariat monitors market behaviour, it should be pointed out that officials are reluctant to apply any price regulatory mechanism except deepening competition. Far from being bridged, this gap still exists and some sectors within the government claim for direct intervention in the marketplace through fixing maximum prices that reflect import costs.

Within this context, three programs to promote energy efficiency at end use level and, thus, related to climate change mitigation, are still in force. They are: the switching from petroleum products to compressed natural gas (CNG) in transport, the fostering cogeneration and a program for the rational use of energy.

The CNG program was launched in mid 80´s and was initially targeted at the taxicab market in the city of Buenos Aires. This market comprises 35,000 motor vehicles, each driving around 250 km/day. To promote the use of CNG its retail price was set lower enough to quickly offset the initial investment for vehicle retrofitting. To this end, gasoline prices were used as a standard that together with natural gas costs set a much lower tax rate than the one levied on gasoline.

This mechanism outlived the restructuring even though it is a subsidy for CNG and its massive use may impinge on fiscal revenue. Precisely, these fiscal revenue problems have lately encouraged the setting up of a new 10% additional tax for diesel oil vehicles whose higher penetration is impinging on the sales of gasoline and hence on tax revenues. This is so because taxation levied on diesel oil is significantly lower than the one on gasoline.

256

Both the fostering of CNG use and the removal of barriers affecting diesel oil vehicles will be required to achieve the substitution levels for the gasoline assumed in the mitigation scenario for urban passenger transportation.

The programs concerning cogeneration and rational use of energy rely mainly on market mechanisms. As regards cogeneration, different studies were made to determine the cogeneration potential in certain manufacturing branches. However, the downward trend of electricity prices at the wholesale market over the last few years, as well as the opening up of the market for large industrial customers, prevented the widespread practice of this alternative electricity supply.

In the specific case of electricity, low wholesale prices together with the vertical disintegration of electricity supply industry, initially discouraged the active involvement of electricity distributing companies in rational use of energy programs oriented to end users. Within their interest in lessening the high electricity demand growth rate, some companies had started reviewing this initial approach. However, the announcement of full retail-level competition and the subsequent re-negotiation of concession contracts for the coming years seems to have altered those plans.

Anyhow, the government standpoint as regards energy conservation seems to be focused on improving users' information by means of adequate labelling of electrical appliances, allowing for customers freely expressing their preferences.

2.2   Results obtained to date

As mentioned before, the opening up of economy has brought about major transformations in energy end-use. Firstly, all economic activities subject to external competition underwent a re-structuring which implied whenever successful, a renewal in terms of processes and productive technology. Clearly, such renewal improved energy efficiency in these activities.

Such restructuring was oriented to improve the products' quality and packaging and also to reduce manufacturing and marketing costs so as to be able to compete in the domestic market in the absence of the protective tariffs they enjoyed in the past. Except for energy-intensive activities, the costs of energy did not play a decisive role in this process. By no means does this imply that manufacturing companies have not taken advantage of all available opportunities to reduce energy costs. However, energy prices by their own scarcely would justify those major investments in the upgrading of manufacturing processes and technology renewal.

The retrofitting of the domestic automobile industry, with a view to MERCOSUR broader market, promoted the manufacturing of more updated cars having less energy consumption. On this basis, it is to be expected that vehicles sold in Argentina in the near future come closer to international standards as far as energy efficiency is concerned.

In this sense, environmental regulations in industrialised countries, rather than energy prices as predicted 20 years ago, are expected to drive the international efforts of the automobile industry to preserve the use of private cars in the future, in spite of the growing concern on their environmental impacts.

However, the substitution of petroleum products in transportation will call for maintaining the incentives through the relative prices of substitute sources. Of course, the effectiveness of these mechanisms will exclusively depend on both prices and mean distances travelled by each type of vehicle.

Less clear seems to be the behaviour of residential and tertiary sectors in meeting their energy requirements.

Imported appliances widened the range of options in the local market and urged domestic manufacturers to meet international standards in terms of energy efficiency for all kinds of devices, especially electric ones.

However, the new options do not always respond to the cultural traditions or to rational use of energy criteria considering the domestic energy resources availability. The most striking examples are the electric devices for home cooking and baking.

In the residential sector and leaving aside the penetration of microwave ovens that supply a particular service, more and more high income families seem to become attracted by good design European electric stoves and ovens. These appliances penetration, though incipient, means to replace natural gas for cooking, which is the main energy source in this use in Argentina.

When considering the whole energy chain from primary energy production to useful energy at end-use level, the overall efficiency of electricity would be less than that of natural gas, despite the high performance of electric cooking devices. The loss of efficiency is even greater when consumers are not familiar with electric cooking and replicate the common practices in cooking with gas.

It might be thought that this loss of efficiency would ultimately affect users' energy costs thus forcing them to review their decision. However, higher costs would only prevent this practice from reaching lower income groups, since energy costs do not play a major role in decision-making for higher income class.

The use of electricity in bakeries is associated with changes in the marketing of foods, moving away from the specific businesses (bakeries) to supermarkets and chain stores selling special baking products. In this case, the penetration of electric ovens is associated to space and infrastructure problems that compensate the higher energy costs. To reduce the use of electricity for bakery purposes seems a task difficult to accomplish resorting only to higher energy prices.

It is only after the restructuring that competition between natural gas and electricity for thermal uses has become more evident, as electricity and gas distributing companies attempt to increase their market share. Following this strategy, natural gas companies are interested in capturing a share in cold air conditioning market, up to now considered as a captive electricity use. On the other hand, some electricity distributing companies are competing for a share in the space heating market with natural gas.

This competition is restricted to specific niches among new users. This means that it aims at guiding the initial decision on the infrastructure to be built up in the new premises rather than encouraging substitution among current users. This competition is restricted to shopping centres, supermarkets and office buildings in the tertiary sector as well as new blocks of flats in the residential sector.

It is still too early to draw conclusions on the likely outcomes from this competition, but it should be highlighted that differences in infrastructure investment for the new buildings will ultimately determine the success for one or other competitor, rather than the relative price of both energy sources. This is reinforced whenever the decision-maker deciding the infrastructure features and paying for it is a different person from who will pay the corresponding energy bill.

2.3   The limits of market-oriented mechanisms

The opportunities offered by competition and market-oriented mechanisms to foster energy efficiency at end-use level, as analysed in the previous section, were taken into account in the baseline scenario as the foreseeable evolution of energy consumption. In this section we will exclusively refer to the actions and instruments that should be applied both to further increase energy efficiency and to achieve the behaviours expected in the mitigation scenario. Thus, we will analyse separately the mitigation actions considered for transportation and in manufacturing.

2.3.1 The transport sector

Energy savings in the transport sector as assumed in the mitigation scenario will mainly rely on building new transportation infrastructure so as to allow for substitution between transportation means and also to speed up traffic and lessen the energy specific consumption in road transport.

The State reforming in the early 90's brought about the privatisation of public transport, still under State control (subways and railways) but also grant concessions for maintenance and expansion of national roads to private companies. These privatisation, however, have not discharge the state from paying subsidies to private operators to prevent the negative impact of an overall increase in transportation costs.

In the future only some traffic lanes will attract private investors to carry out the works. Therefore, a strong State intervention will be required in the design of transportation policies and in the promotion of the necessary infrastructure works to reduce energy consumption.

As regards the mechanisms to be used, we shall mention mandatory regulations in the first place such as:

- Setting up preferential lanes both for public transport and private cars with more than one passenger so as to encourage higher cars' occupancy factor.
- To ban private cars' circulation in some downtown areas, while improving the public transport service in the area.
- Strict vehicle control over safety and energy efficiency conditions. This may eventually lead to setting up restrictions on outdated models to qualify for driving on streets and roads. If this were the case, users should have access to loans so as to guarantee constant vehicle renewal, especially vans and light-duty trucks.
- An agreement with local car manufacturing companies on the main features to be fulfilled by all vehicles launched into the market; with special reference to the number of vehicles fuelled by other energy sources than petroleum products. This mechanism should be likely supplemented will economic incentives or penalties such as differential taxes for categories among others.

However, these mechanisms are not enough to promote the required infrastructure in terms of roadways, railways and subways needed in the mitigation scenario. Given the high incidence of transportation costs on the retail consumer price index, the State shall intervene in searching funds for the works and ensure reasonable retail transportation rates. To avoid imposing an extra burden on local taxpayers, some external financing should be necessary. In particular, international funds for implementing mitigation actions in developing countries could be partially allocated to finance this works.

2.3.2 The industrial sector

As previously stated, although the process resulted in a significant economic concentration, the economy restructuring had a positive impact on energy efficiency due to both technological renewal and the increase in production scale. To rely on competition as the sole promoter of higher efficiency, would later bear the risk of deepening the already high economic concentration rates, hence risking the survival of small and medium sized companies.

Since these are the companies that most contribute to the support of employment in the secondary sector, their progressive disappearance would bring about an unbearable social cost. Therefore, the mechanisms for implementing mitigation actions in manufacturing activities should focus on small and medium sized companies that are going through tough times while still in the process of becoming more cost effective.

Lately, energy service companies (ESCOs) are one of the most widely promoted mechanism to foster improvements in energy efficiency due to their alleged better adaptation to competitive environments. Basically, an ESCO is a company that offers to audit and diagnose potential energy savings at a manufacturing facility and takes the responsibility for making said savings effective in exchange for a given percentage from the total energy bill savings.

It is true that the existence of these companies helps a continuous updating on the most effective processes and technologies available at international level, particularly because ESCOs can be specialised in different productive branches. However, the survival of an ESCO lies mainly on the existence of considerable differences in energy costs before and after facilities retrofitting, allowing for a short-term investment recovery so as to expand their activities by capital recycling.

It is worth wondering whether this mechanism is really effective to involve in energy conservation actions productive companies that otherwise would feel that the economic incentive of energy costs savings were unattractive. Their ability to involve small and medium-sized manufacturing companies in energy conservation seems doubtful. The main doubt is to what extent the small-sized firms can constitute an appealing market for ESCOs, since the manufacturing companies would be very interested in a mechanism that entails all benefits and no risks whatsoever.

In this context and taking into account the market mitigation policies are aimed at, government actions should focus on three aspects: access to information, an energy auditing system and access to funds for paying retrofitting investments.

Regarding information, Argentina has a National Institute of Industrial Technology (INTI) that was precisely set up for granting State's support to the industrial development of the country. This structure could well be reinforced and enlarge present efforts in systematising and disseminating updated information on the latest technologies and more efficient productive processes.

Even being unavoidable, information does not suffice to ensure small and medium-sized industries retrofitting, given the great diversity of specific situations. Therefore, a support program for small enterprises should be implemented, including energy audits as a diagnosis for recommending definite steps to be taken by each surveyed company. Under INTI supervision, local Universities may join in this program, as was the case in former pilot projects.

These programs would raise awareness on the prospects of energy saving and other advantages stemming from productive process restructuring in small and medium-sized companies.

However, special attention should be paid to two additional aspects: how to fund the program and move from the diagnosis to the action stage.

Fixing a reasonable rate and imposing mandatory audits (as done in other countries after the oil crisis at late 70's) entails some risks as it might endanger the survival of those companies being targeted by the program. However, it would seem reasonable that a part of companies' savings from recommended actions would turn back to financing the auditing program to widen its scope.

For effective implementation, the financing terms will become the key issue; regarding both interest rates and payback terms. It should be pointed out that prevailing borrowing terms for small and medium-sized companies are much more unfavourable than for large economic groups.

The setting up of preferential finance schemes may help both overcome current difficulties in these companies and implement energy conservation options. To support such programs, international funds aimed at encouraging mitigation actions in developing countries could be used.

In addition to these measures for helping small and medium-sized companies' retrofitting, the effective way to encourage heat and electricity cogeneration in industries should be found out.

Electricity generating companies have taken part in some cogenerating experiences at industrial level by means of two different approaches. In the first approach, a manufacturing plant located near a thermal power station contracted the joint supply of electricity and waste heat from the power plant. Although this is a novel and interesting experience in Argentina, it remains restricted to customers sited nearby the power station.

The other approach was through a contract to build, operate and maintain a cogenerating facility in the customer's premise. Through this contract, the industrial company purchases heat and electricity from the generator, which uses a portion of the premises and can market electricity surplus in the wholesale market.

Though it might be restricted to large potential cogenerators, this mechanism seems to be attractive because it overcomes one of the barriers to cogeneration. Mainly, the reluctance of most industrial plants to install their own electricity generating facilities, as they prefer to focus their technical teams on tasks related to the industrial process itself. It would be necessary to analyse in detail the results obtained by both parties involved in this experience and look for ways of promoting this type of supply not only for large industrial concerns but also for smaller ones located in the various industrial parks throughout the country.

As far as smaller industrial plants outside industrial parks, the promotion of cogeneration could be done jointly with similar mechanisms to those suggested for energy conservation.

3   Energy efficiency in energy supply

In the case of energy supply, official policies also rely on market forces to gradually achieve higher efficiency in energy supply industries, at least in those energy markets that have shown higher competition levels.

Up to now, data on experiences in the electricity industries, both at generation and distribution levels, shows that companies aim at taking full advantage of all opportunities to

improve their revenues and competitiveness in the marketplace cutting down on losses within the system.

In the case of electricity generators, there is a growing interest in power plants' increased energy efficiency. Suffice it to say that the first power plants set up by private investors after the restructuring had an efficiency of 33%. Three years later, in 1997, the power stations that are joining the system have 54% efficiency. Competition among generators at the wholesale electricity market seems to be comprehensive enough so as to compel generators to take full advantage of all the opportunities that technology advance offers to reduce power stations' heat rate.

Distribution losses in the country are quite diverse depending on the region. Distributors in the metropolitan area are authorise to charge to end users an extra 14% on the purchasing price at the wholesale electricity market to account for distribution losses in low voltage. When licenses were granted, energy losses reached 27% of the total energy injected in the distribution grid. Thus, companies tried to improve the consumption metering and eliminate tapping as quickly as possible to prevent the economic losses that such a situation entailed. Within four years, they were able to bring low voltage losses down to 14%. Any additional reduction to be achieved in the future will be to their advantage since they are not forced to transfer those benefits to end users through rate reductions.

This 14% ceiling still seems excessively high, although a significant part of the distribution grid is aerial. Hopefully, companies will aim at reducing distribution losses well below this 14% ceiling provided the cost of energy saved is above the investment required to achieve such loss reduction.

In future, the greater their market share, the higher their interest in lowering distribution losses will be. In the event of full retail competition as proposed by the Energy Authorities, special attention should be paid to this issue when setting distribution rates. Otherwise, it will not be easy to reach the loss reduction levels assumed in the mitigation scenario.

Distribution losses are still high in several regions in the country. Although all distributing companies have shown some concern on the present losses and their interest to drastically cut them down, caps on distribution losses that can be charged to retail payers differ from one jurisdiction to another.

For other energy industries, the higher opportunity to improve efficiency turns out to be the treatment of the associated natural gas in the oil fields. The expansion of oil production after the restructuring, driven by exports, brought about an increase in the volume of gas vented in the oil fields.

Clearly, the value of vented gas, from the point of view of oil producers, was not high enough to compensate the recovery and/or re-injection costs. Surely, in this perspective, the timeframe plays a role in gas reserves appraisal. From the oil companies' standpoint, the re-injected gas would only provide additional revenues after the depletion of the reserves existing before gas re-injection. Therefore, present re-injection costs should be compensated by the present value of gas sales once reserves are depleted. Since reserves have a time horizon of about 20 years, it is quite reasonable that vented gas is of little value for oil companies.

This different appraisal of the depletion cost of a non-renewable resource as natural gas accounts for the lack of effectiveness of market forces to lower the gas waste. On these grounds, the energy authorities resorted to stringent regulations to reduce the amounts of gas vented in the oil fields, as discussed in Chapter VII.

As previously noted, these rules clearly constitute a mitigation action already implemented by the government and they may alter the economic equation of oil production in some oil fields, specially with the current low international oil prices. Oil companies should decide, in each case, if crude-oil production keeps its economic appeal under these new regulations. For the moment, an important reduction in the volumes of gas vented in the fields is already seen.

4 The promotion of non-emitting energy sources

We will herein refer only to the use of non-emitting energy sources in electricity generation, as it is the main use of these sources assumed in the mitigation scenario. Therefore, we will consider hydropower, wind and nuclear generation, by reviewing the following aspects:

- Policies in force
- Market trends
- Main barriers to their use
- Promotion mechanisms

4.1 Policies in force

Being Argentina a federal country, the incentives and policies in force both at national and provincial level will be analysed whenever required.

4.1.1 Hydroelectricity

Each province owns the hydroelectric resources within the provincial territories. However, inter-provincial rivers are under the control of federal government, which grant licenses to build and operate the hydroelectric developments on these rivers. On the other hand, provinces participate in the control of discharged flows and their impacts.

Even when no incentives exist for building new hydropower stations at federal level, the federal government retains its responsibility for making all the information on new hydropower developments readily available to any interested investor. This comprises:

- Permanent assessment of the hydroelectric potential in the national basins.
- Permanent updating of potential hydroelectric undertakings.
- To ensure the optimum use of hydraulic resource through defining the possible sites and the design-variables for the new works.
- Submission of relevant data (pre-feasibility studies) to the parties interested in building the new works.

Some provinces have proved to be more active in fostering the construction of hydroelectric works in provincial water flows. Among the cases recorded to date and after the restructuring, the provincial governments have accepted to participate in the funding of the works, even in cases where the execution and subsequent exploitation were in private investor's hands. By means of this mechanism, such power stations building, operation and maintenance license was granted to the investor groups whose bidding required less investment by the State.

4.1.2 Nuclear energy

Topics related to nuclear energy are of federal government competence. Presently, nuclear power stations are in the hands of the State, although a law has been passed to enable the Executive Power to privatise them.

The State-owned company that runs the nuclear power stations gets the same price as other generators at the wholesale market, but it is not authorised to enter into supply contracts. The new law establishes a number of liabilities for a prospective private operator regarding:

- Risk of nuclear hazard and corresponding indemnity insurance
- Contingency fund for building the final repository for irradiated elements.
- Contingency fund for the decommissioning of power stations at the end of their useful life.
- Support tax for the Nuclear Regulatory Body.
- Contribution tax to the National Commission of Atomic Energy.

Additionally, the investor interested in running the existing power stations should commit to complete the works for the third nuclear power station, which are almost interrupted at present.

In the current context of wholesale electricity prices, these conditions cut down the private investors' interest to take over the existing nuclear power stations in the country, which also have technology differences between them. It seems that even the government, which pushed the enactment of this law, doubts on the amount that could be collected through privatisation of nuclear power stations and is delaying the call for bids.

Of course, a number of special requirements should be met for the construction of new nuclear power stations. These requirements relate especially to safety issues and different national and provincial entities should give their authorisation for the project before granting the concession.

4.1.3 Wind and solar energy

There is an explicit promotion for the use of these sources only for the supply of dispersed and still unserved small systems, not only at national but also at provincial level. However, the main goal of these measures is to expand the electricity service to the populations that have not been supplied yet.

The national program is similar to the one put into practice in some of the northwestern provinces of the country. By this program, a license is granted to a private investor for installing, maintaining and running the necessary decentralised facilities to render the service. The licensee can choose the generating technology according to local energy resources, but the program is mainly oriented to promote the use of solar photovoltaic cells.

The program, which is funded by the World Bank, foresees to grant subsidies to the licensee during the first three years of the license to cover up to 50% of new users' electricity bill throughout said period. It is too early to analyse the outcome of this program.

4.2 Market trends

As stated before, since the restructuring, private investors have clearly shown their preference for using natural gas in electricity generation, formerly resorting to open cycle gas turbines and lately to combined cycles.

Except for their interest in taking part in the privatisation of installed hydroelectric power stations, there was no private initiative to follow the pathway opened by public companies towards the use of the country's hydroelectric potential. In this sense, the only positive experiences were the construction of a few smaller hydroelectric power stations, materialised through provincial governments' subsidies.

Private investors seem to be even less attracted to invest in new nuclear power stations whose costs are non competitive in the current context of the wholesale electricity market. The more restrictive the regulations regarding nuclear safety, the less competitive nuclear electricity, in turn influenced by a growing resistance from certain social groups to its use.

Wind energy in Argentina was very popular in rural areas, especially used as power to procure water for livestock. Wind turbines for electricity self-production had a much lower penetration in scattered rural areas not supplied by the public electricity grid. Only in the last years, wind turbines have been adopted as public service facilities in certain areas of the country.

Given the lack of incentives, wind turbines installation depends on the conditions prevailing in each particular location for the electricity service. Apart from the wind resource availability, the main determining issues are the distributor's purchasing price, the extra-high voltage and regional transmission costs and the retail electricity rates. On this basis, some electricity co-operatives have been able to install around 3.6 MW in windmills, although their production cost during the depreciation period is more than twice the electricity price at the wholesale market.

In case of full competition in the end-use electricity market in the future, the continuity of this type of equipment could be endangered. Since higher local prices could encourage users to hire their supply from other generator, electricity co-operatives would become unable to keep costly generation in the absence of the rate protection they currently enjoy.

4.3   Main barriers to the use of these sources

In this analysis, two different types of barriers that may hinder the use of these sources will be described: popular acceptance and economic barriers from the investor's perspective.

Regarding popular acceptance, it should be pointed out that some social groups are changing drastically their perception on nuclear energy and hydroelectric undertakings, mostly due to the poor past management of local impacts and hazards posed by such undertakings.

The appropriate management and protection of water flows is one of the most important environmental problems that should be dealt with in Argentina. From this standpoint, perhaps, one of the most problematic issues are the works of the Del Plata basin that are precisely the ones considered as mitigation options due to the volume of the likely generated electricity.

It is important to highlight that it is a flatland region crossed by two rivers, especially the Paraná, up to its mouth in de la Plata River and the Atlantic Ocean. In the high basin of the Paraná and its tributaries, in Brazilian territory, there are many hydroelectric power stations, that in spite of their storage capacity are unable to regulate the flow of both rivers characterised by a rainfall regime.

Much has been said and published about the risks of the spread of diseases (schistosomiasis) favoured by stagnant water environments, diseases that particularly affect the local population. This issue is present in the public opinion in an on-off basis. Nevertheless, among the greatest concerns of local inhabitants are the flooding of fertile soils and the moving of the population as a result of dams, water drainage and flood prevention.

Cyclically all the area suffers significant economic damage from floods caused by the intense rainfalls. The climate variability associated to the El Niño phenomenon seems to be increasing both frequency and intensity of floods, which results in growing claims from the population for some works to mitigate its devastating effects. Indeed, in some occasions the construction of defence works has not only worsened the drainage conditions of the waters but has generated conflicts among surrounding towns as well.

Given the topographic features of the region and the river flow, it is clear that dams would add very little ability to freshet regulation. However, one of the projects foresees a side dam for the protection of productive lands on the lower bank of the river. Yet, there is doubt as to the impact that this side dam might have upon the behaviour of ground water and the area's drainage system.

Therefore, it will be necessary to ensure that hydroelectric works are part of an overall plan to properly handling water resources in each region. Only sound research work, surveys, and the broad involvement of local social organisations will enable to dissipate local inhabitants' fears on the damages that such works might cause.

Hence, the works' design cannot depend only on to the economic benefits of the investors that will carry them out. Instead it will require a strong commitment by the State to ensure that the set of local impacts and affected inhabitants' aspirations are not overlooked; otherwise, the viability of its execution would be highly jeopardised.

As to public perception on the risks of nuclear power, the situation has also undergone a dramatic change in the last years. After the last amendments, the Constitution for several provinces in the country includes adverse statements on the use of this technology in their territories. Mostly, they declare their jurisdictions free from nuclear elements. The highest resistance comes up when facing the possibility of being recipients of nuclear wastes, although the installed nuclear power stations has been producing nuclear wastes for almost 25 years.

It will not be an easy task to restore public trust over this technology. There are still too many doubts on the long-term safety of repositories for highly radioactive wastes. A thorough debate and the involvement of local organisations will be also required to render viable this non-GHG emitting technology.

As to the economic appeal to build this type of works, from the private investor's perspective, many obstacles account for the trend shown by generators in their technology choice. To better understand their behaviours, it should be kept in mind that generators have either to manage to sign supply contracts or to get their units to be dispatched for receiving any revenue from selling electricity. They also get a reward for the generating capacity put at the system disposal whenever their units are accepted in the weekly bidding as cold reserve or if they succeed to sign a reserve contract.

Although differences exist, most distribution licenses aim at ensuring that distributing companies will assume the risks of contracted supply, by banning the pass through to retail rates of any difference between the hired and spot price at each time. Thus, distributing companies are discouraged to hire their supply when spot prices have a downward trend, while generators are reluctant to enter into supply contracts when prices are expected to grow.

As distributing companies seem to be risk averse, all the risks on future price fluctuations would be undertaken by both those generators having no contracts and the captive consumers, who have to pay retail rates in line with the spot price.

Under these circumstances, all the generators face the risk of spot price volatility, which is remarkably enlarged by movements in hydroelectricity supply. It should be pointed out that most of hydroelectricity in Argentina comes from run-of-river power plants, whose generation at each time depends on the water inflow. This share would be even higher in the mitigation scenario because of the type of hydropower stations added.

During wet years, the operators of run-of-river power stations may partially offset losses from lower prices with higher electricity sales, but the net outcome on their revenues will depend on the extent of both phenomena.

Nuclear generation is expected to remain unaffected by a higher hydro supply because its low running costs. Consequently, the revenues of nuclear operators would strictly follow the spot price fluctuations provided their production is sold in this market.

In theory, fossil-fuelled generators would suffer the most from higher hydro supply, as both the selling price and the amount sold would be lessened. In some cases, they might even be excluded from the dispatching. To mitigate this damage and prevent the bankruptcy of those generators whose power plants would help face dry years; the rules were amended to include a special reward to fossil-fuelled generators for maintaining their generating capacity at the system disposal.

To that end and when planning the system's load dispatching for the next season, those thermal units that would be dispatched under the driest recorded condition are determined, as well as their generation level under such specific circumstance. This generating capacity, named as thermal base-load reserve, is always paid for regardless of the expected short-term hydraulic condition.

As fossil-fuelled generators will benefit the most from dry years (by selling more electricity at higher price), one could wonder whether the base-load reserve should be estimated for the driest year or some intermediate situation should be considered. Any way, the rules must ensure enough back up thermal generating capacity in the marketplace to be able to maintain a continuous supply during draughts.

Nuclear generators will also improve their revenues in dry years. They receive no payment for base-load reserve capacity in the understanding that nuclear plants will always be dispatched under any hydraulic condition. On the other hand, the impact of dry years on hydroelectric generators' revenues will depend on both the extent to which their own generation is reduced and the spot market price increase.

Of course, the range of hydroelectric generation fluctuations between rich and dry years depends on the plants capacity flow. It should be pointed out that all the existing hydropower plants in the country have an installed capacity that allows for taking utmost advantage of hydraulic potential. Therefore, hydropower plants are able to discharge most of the water inflow in wet years and, thus, hydroelectricity supply fluctuates as much as water inflows.

It is unlikely that private investors will be willing to follow this design rule. Most likely, the equipment will be that which permits to offset investment in additional groups with higher income, in spite of eventual price drops. It will be necessary to analyse in each particular case the real meaning of such decision rule, in terms of the hydraulic power unused due to spilling.

In the future when the Argentine and Brazilian power systems become interconnected, spot prices in Argentina will be influenced by the hydraulic conditions in Brazil. It must be emphasised that the Brazilian power system is supplied almost entirely with hydroelectric generation and, thus, it is subject to flow distribution. The needs for additional generating capacity are defined ensuring supply for the 95% of the time. This means that while power shortages may occur 5% of the time,

95% of the time an excess capacity without an own market to place the surplus should be expected. Such electricity in excess, whose amount depends on each hydraulic year, is named secondary or non-firm electricity.

The economic value of the secondary electricity, in terms of its marginal cost of generation, is null, since it corresponds to a spilling situation. Therefore, the price to be offered in the Argentine market, as a contingent import, could be very low provided it covers transmission costs.

It is important to point out that the first "strong" interconnection between both systems will be laid to channel firm capacity contracted by a Brazilian company with Argentine generators. The contract considers the supply of 1000 MW, which could be raised to 2000 MW in the near future. The fact that firm capacity is hired means that the Argentine generator will be summoned depending on own supply availability in the Brazilian system. For the sake of having this reserve available the Brazilian company commits to pay U$S 62 millions per year, that may be doubled in case the effective generation of these units is required.

Under these terms, the export contract will have a double effect on the Argentine spot market. Whenever there is water surplus in Brazil, the Argentine contracted generator will not export but will be able to offer its idle capacity at the Argentine spot market. He would also be in a position to offer an exceptionally low price, since part of its revenues will derive from the power sold to the Brazilian company. The tendency to adopt this attitude would be strengthened if he has to hire its gas supply under the "Take or pay" modality.

Clearly, this context discriminates against capital-intensive power stations with long leading times, since the higher the risks the higher the rates of return for the investment expected by private investors. In fact, all technologies considered as mitigation options share this characteristic. In the case of hydroelectric power stations long distances to load centres force hydroelectric generators to face additional high transmission costs.

Leaving the risks aside, some special regulations also increase the cost of mitigation options from private investors' point of view. In the case of nuclear generation, as already mentioned, some additional costs exist regarding both wastes treatment and the reserve for decommissioning, as well as the insurance costs and the supporting rate for the nuclear regulatory body.

When building a hydroelectric power station the following should be taken into account:

1.   *The term of the license to operate the power plant*; same covers a 30-year period, much shorter than the hydroelectric complex useful life estimated in 50 years;

2.   The payment of royalties to the provinces which convey the use of the hydroelectric resource. Same accounts for 12% of the gross revenue for energy sales, in cash or kind.

3.   *The procedures for transmission network expansion*, which leads new lines installation costs to be amortised in 15 years at most.

These additional costs affect the perception of private investors on the economic benefits that they should earn with the building of the works. Therefore, such costs should be included in the estimates of incremental mitigation costs if a change in the generators' technology choice is to be encouraged.

By way of example, Figure 101 shows the impact of these issues on incremental mitigation costs for the most cost-effective hydropower station included in the mitigation scenario, assuming a future gas price of U$S 1.8 per million BTU.

The curve labelled as "Public" in the figure corresponds to the costs for an assessment from the public perspective. That is, to consider the useful life of the power station and the associated transmission lines as the payoff period for the investments and to exclude from costs any tax, as taxes is a mechanism for rent capturing rather than a cost. The curve labelled as "Private before taxes" corresponds to reduced amortisation term for the investments: 30 years for the hydraulic works and to 15 years for the transmission lines. On the other hand, the curve "Private after taxes" includes as cost for hydroelectricity generators the payment of royalties to the provinces.

Figure 101 Public versus private perspective in the estimates of incremental mitigation costs
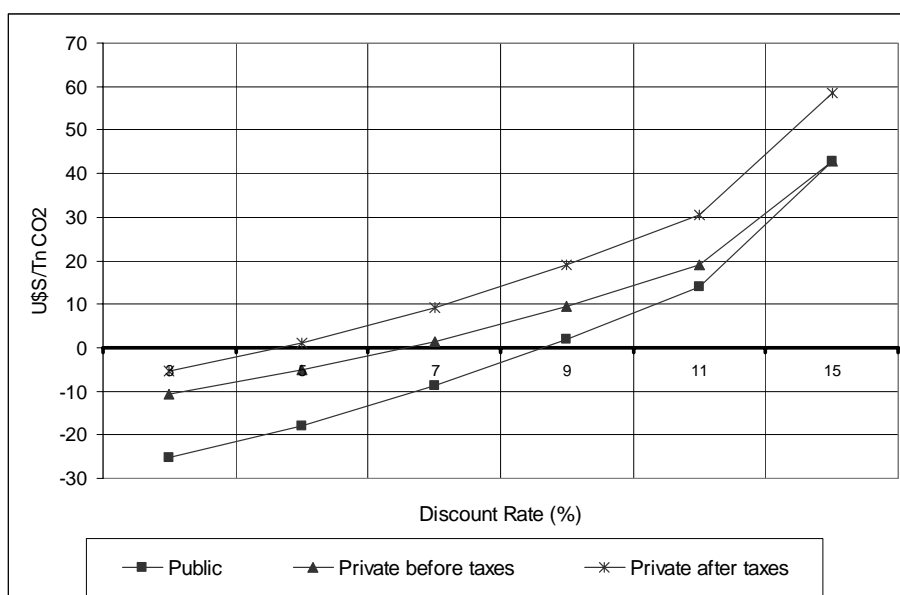
As seen in the figure, private investors will be operating at a loss even if 5% discount rates apply, although the project had proved advantageous for society as a whole at rates lower than 9%. At a discount rate of 11%, which is relatively low for private investors standards in Argentina, private mitigation costs are over twofold the cost from the public perspective (30.4 U$S/Ton of CO_2 Versus 14 U$S/Ton CO_2). The mechanisms used to implement mitigation actions should compensate for this economic damage.

4.4   The promotion mechanisms

Some important questions should be kept in mind when selecting the mechanisms to promote the installation of power stations with GHG emission-free technologies. They are mainly as follows:

1. Who should bear the generator's higher costs?

2. How to channel subsidies?

3. How to combine private generators' initiative with the obligation to implement mitigation actions?

Some countries, all of them included in the Annex I of the United Nations Framework Convention on Climate Change, have implemented different market-oriented mechanisms to promote the use of renewable energy sources. The most commonly used are the carbon tax, externalities adders; renewables set-aside (be they centrally managed or through a market of renewable energy credits); tax credits, preferential finance, green marketing; etc.

End users have to pay for this promotion whatever the above-mentioned mechanism used, in some cases through higher electricity retail rates and in other cases as taxpayers.

In a country like Argentina, one might wonder whether the use of such mechanisms to capture funds meets the smallest principle of international equity in climate change mitigation. Particularly considering that as a non-Annex I country, Argentina has no commitment to abate GHG emissions in the near future and its emissions are and will remain to be quite lower than in industrialised countries.

In our view, Argentina's willingness to both contribute and take part in world-wide efforts for climate change mitigation should mean neither a financial nor an economic burden for the local population. Thus, here in below we will discuss only the effectiveness and obstacles to promote clean technologies under the prevailing context for the Argentine power system. As far as program financing is concerned, we assume that international funds for mitigation actions will be used and channelled resorting to any of the mechanisms that are still under discussion in the Conference of the Parties. On this basis, both carbon tax and green marketing, as well as any other incentive implying higher costs for end-users, are ignored in this analysis.

Most of the incentive mechanisms are used to guarantee a small share of the electricity market to new generating technologies and they aim at giving support to small-scale generating facilities using renewable sources (wind turbines, mini-hydro and photovoltaic cells). Some doubts still exist on their being equally cost-effective for large hydroelectric and nuclear power stations as for the promotion of decentralised wind generation.

In the case of setting-up supply quotas, both hydro and nuclear electricity should be included in Argentina as promoted technologies, while they were excluded in all the countries that have already implemented this mechanism (Great Britain, USA, Denmark, etc.) However, some of the hydropower plants included in the mitigation scenario account, in each case for about 20% of the total supply. This, in turn, generates indivisible supply blocks that hinders effective competition and may produce market distortions.

An additional question is whether existing hydro and nuclear generation should be excluded or included in the established quota, considering that presently some 50% of total supply come from this type of power plants. The exclusion of existing hydro generators may led to unmet the hydro quota in the event of low water inflows in the new hydropower plants, even when the existing plants could compensate such loss of hydro generation. Their inclusion however should not imply a channelling of subsidies towards them.

The other topic refers to who should meet the quotas defined. The possibilities are generators, electricity traders, distributors and end users. End users are ruled out because it is assumed that they will not cover the incremental mitigation costs.

To impose the meeting of the quota on distributors is, in theory, the most suitable way provided they supply a substantial portion of end-use demand. However, distributing companies may loose most of their present market share in the near future when the retail electricity market became full competitive.

Electricity traders are already in a position to act but it is too early to foresee if their market share will be large enough to undertake by their own the commitment of meeting the established quotas, as they have to compete with distributors and generators.

Generators can not be forced to comply with production quotas per type of technology with their own generation, because supply is highly atomised, although it would be easier to control their

fulfilment at generation level. Such obligation would lead to implement a market for renewable energy credits, which would allow thermal generators to prove that another generator has produced their clean electricity quota.

If this were the case, the existing hydraulic, nuclear and wind generators could not negotiate their certificates since that would mean a subsidy without an investment counterpart. However, their generation will be necessary to meet the established quotas.

By selling renewable energy credits, non-emitting generators are expected to collect as much money as needed to offset their higher production costs. However, the existence of specific funds to cover incremental mitigation costs assumes that the agents that purchased the credits will be compensated for such extra cost.

The problem lies on how to measure and control that this extra cost is reasonable and that non-emitting generators are not making huge profits. When a distributor purchase clean energy at an above-market price, as was the case in Great Britain, the compensation to the distributor can be set using the spot price as a standard for the cost of alternative supply. On the contrary, when transactions take place in the secondary certificates market no specific signal from the electricity market exists and ceiling prices should be defined, certainly a difficult task.

The other topic, also related to who is forced to abide by the quotas, concerns the treatment of imports and exports. If it is the generators' duty, the control of emissions from domestic power stations shall be guaranteed regardless of their destination market. If this duty lies in the hands of those selling to end users, a clearer definition is needed on the role played by eventual imports, especially from Brazil.

In view of the above, we may conclude that this topic deserves a much deeper analysis on both all difficulties to implement this type of mechanism and its effectiveness to foster bulk production from non-emitting technologies without causing market distortions.

An alternative type of mechanism to promote the construction of large non-emitting power stations is a higher government involvement through a call for bids to build and operate the works setting the estimated incremental cost as a ceiling for subsidies. In such a case, bidders would compete on both the requested subsidy within the accepted range, the royalty they are willing to pay for the license, additional works offered and other improvements in the area.

This more traditional and presumably simpler mechanism is not free from difficulties. The major ones are the role assigned to the private initiative (technological choice, new opportunities' detection, etc.) and the timeliness to call for bids depending on the electricity supply needs. The timeliness is a critical issue because the power stations to be bid could have a strong impact on the system's operating conditions. In case that such mechanism was chosen, special attention should be paid to the transparency and early dissemination of information in order to avoid unnecessary risks. In any case, such a process would require enough time to reconcile viewpoints and attain the minimum consent of local people, eventually affected by the works.

These comments on the different types of mechanisms to promote non-emitting technologies do not apply to wind generation, which could however get to cover a growing share of the electricity market. In this case, the bidding process with limited compensatory subsidies would also seem the simplest implementation possible, since the control of quotas poses difficulties similar to the ones highlighted for the remaining technologies.

Annex 1: Methodological issues in defining climate mitigation policies

1 Methodological issues in defining a mitigation policy for Argentina

As seen in this report's Chapter II, the economy restructuring and the energy deregulation at the beginning of the Nineties substantially modified the role of the State, restricting its former capacity to influence the energy supply and consumption structure. The privatisation of public energy companies plus market-oriented regulations notably reduced the government involvement in energy supply channelling, leaving decisions on supply expansion and even on the use of domestic energy resources in the hands of private investors. At the same time the state's influence on energy consumption decreased because of both the privatisation of certain energy intensive industries and transportation companies and the desertion from the domestic energy pricing policy that historically favoured petroleum products substitution.

Although the absence of governmental interference in energy markets may have been a positive signal for private investors when deciding their entry to the domestic energy markets, such attitude may limit the public capability to implement a climate change mitigation policy that will necessarily clash with such private agents' interests. Actually some of such conflicts have already surfaced as a result of the Parliament's intention to legalise, through the new hydrocarbons act, the government intervention in the oil market when exceptional circumstances so demand.

According to what the new act states, the amendment of the legal body on which privatisations were based results from recognising these markets as oligopolies. Ownership concentration in some energy industries in Argentina favours the emergence of conflicts between private interests and public policies, be they energy-related or aimed at climate change mitigation. This is in our view one of the key issues to take into account when designing policies and their implementation, as their feasibility (and also their desirability) will depend on the final recipient of their impacts.

Within this context and under the economic organisation existing in Argentina, to make climate change mitigation policies fit the economic and social development poses three types of different methodological difficulties:

1. to deal with conflictive decision criteria, whose relative importance is related to the satisfaction level attained in each of them.

2. a high degree of uncertainty resulting not only from the decision process' context but also from the weakly knowledge of the decision maker's preference structure, which is continuously changing with his growing awareness on both the possibilities to influence the system's behaviour and the obstacles to do it.

3. the number of economic and social agents involved in implementing mitigation measures and affected by them, whose role in the decision making process is non-institutional.

Precisely, for the sake of an operational methodological approach to the decision process, ways to solve and integrate the three types of problems will have to be defined.

1.1 Dealing with conflictive expectations

From the methodological point of view, a conflict arises whenever expectations or objectives are defined in a way that the achievement of one of them impairs the situation relative to another equally desirable expectation or objective. Almost all decision processes, even in our daily life, generate such kind of conflicts and decisions become a trade off regarding expectations to be attained.

From this perspective, two large conflict categories can be defined: between *individuals* involved in the same decision process and *between decision criteria* upheld by the same individual. In the first case the problem is addressed from different individual viewpoints, surely with conflicting interests. Such kind of conflicts will be discussed in Section 1.3 below whereas the methodological problems posed by dissimilar and conflictive interests in the choices made by a single individual shall be addressed now.

As from the '70s numberless papers were published on the development of methods and models to represent decision processes based on multiple attributes or decision criteria. In spite of such efforts their use in real problems solving has been extremely meagre, especially to deal with complex systems characterised by a large diversity of alternative options. To address such problems, efforts in the methodological and modelling approach focused mainly on multicriteria optimisation techniques, trying to contribute a certain rationality in pre-selecting alternative decisions.

The first step in all these techniques is to screen all available options, retaining only the alternatives that evidence true conflicts between objectives, technically called Pareto-optimal or non-inferior solutions. Alternatives *A* and *B* are non-inferior if at least a couple of evaluation criteria (*objectives*) are truly conflictive. That is, following one criterion, *A* is preferable to *B* and according to the other, *B* is preferable to *A*. All possible decisions are in the dominance cone of at least one Pareto-optimal alternative. Therefore, in principle, establishing the decision-maker's preferences regarding the non-inferior set of solutions should suffice.

However, in most decision problems related to public policies (on any matter or sector) non-inferior solutions are too broad for the decision-maker to directly inspect and evaluate. Therefore, one cannot apply techniques based on the ex-ante building of the decision-maker's utility function, which associates a numeric value to each alternative solution to illustrate their order according to his preferences. It should be noted that the cost-benefit analysis and the use of weighting factors or fix numerical priorities between criteria are special ways for ex-ante building the decision maker's utility function, as long as multiple aspects comprised in the decision are cut down to an unidimensional value representing his preferences.

The first practical drawback of this approach is the difficulty or impossibility to define comparable rating scales to assess each alternative solution's performance relative to various decision criteria. Poor choosing of rating scales may significantly bias results and remove them from the decision maker's true preferences' structure. The even more serious second difficulty lies in that the priority assigned to each criterion **depends** on the alternative's compliance with such decision-making criterion. A slight decline in employment, for instance, is not appraised the same under full employment conditions than when high unemployment exists.

The persistence in using this type of techniques, in spite of the above-mentioned difficulties, arises more from the need to separate technical and political analyses, rather than to its effective

274

ability to capture the multiple attributes of the decision making processes. In effect, whenever the decision-maker's utility function is defined in advance the interaction between technicians and the decision-maker may be reduced to an initial contact, leaving it for specialists to analyse the problem and identify the "best solution". To a certain extent this is the natural path followed to find analysis methods that are sufficiently neutral and reduce subjectivity.

However, subjectivity is an intrinsic element in any decision making process having more than one appreciation criterion. The choice between two non-inferior alternatives can only be made through a judgement of value, which is —in nature— subjective and variable from one decision-maker to another. The links between economy and environment, and particularly, the dilemma between a fast economic growth and the preservation of the environment is a clear example of individual —or even collective— appreciation subjectivity. The different priorities attached to both aspects of economic development have permitted to relocate environmentally aggressive economic activities without a strong rejection by recipients.

Assuming the decision-maker's legitimacy to make decisions that in some cases pertain to the society, one should remove from subjectivity the notion of "arbitrariness", historically attached to it. To that end methods should help explain the decision-makers' preferences and ensure consistent decisions.

Accepting subjectivity involves a decision making process based on a long chain of analysis-decision interactions and the use of tools allowing the decision maker's significant involvement. Some methodological and modelling developments have followed along this path. The complexity of the searching process induced firstly to change the criterion for solutions' acceptance, shifting from optimisation to satisfaction. That is, there is no sense in pursuing the best of "all" the alternatives (optimum), it suffices to find "one" which is good enough (satisfactory).

However, the use of such techniques disclosed the difficulties a decision maker may face to make his own preferences' structure clear given his ignorance about his true possibilities to influence the system's path, which leads us to the second type of methodological problem briefly discussed in next section.

Even if conventional techniques and models were used for mitigation policy analysis, one should try to capture the complexity of a multiattribute decision making process. To that end, the usual representation of energy flows should be modified and impact indicators should be added to help searching for an acceptable *mitigation scenario*, as detailed in this Annex's Section 2.

1.2   The scope of uncertainty

When starting the search for satisfactory solutions in analysing "complex systems", the decision-maker follows his structure of "desires", i.e. his "ideal structure of preferences". As the process progresses, the decision-maker perceives the system's rigidity and some difficulties to alter its trajectory thus, his structure of preferences[40] moves from "the ideal" to "the possible".

From the traditional decision theory perspective and its methods of analysis, such transformation of preference signals by the decision-maker is perceived as a logical inconsistency that might invalidate the whole preceding searching process. Consequently, and

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[40]   Normally indicated through his marginal choices represented, for instance, by the marginal substitution rate between objectives.

from a methodological point of view, the sequence of alternatives retained in the searching process may not converge towards a growing satisfactory solution. It is clear that consistency —or inconsistency— problems depend on whether truth judgements are ratified. Traditional mathematical techniques, based on a bivalent logic, could be conspiring against success on addressing this problem.

The traditional proposal of using probabilities to deal with uncertainty (either objective or subjective) seems inappropriate to address the uncertainty coming from the decision maker's weak knowledge on his true capability to influence the system, which makes his true preference structure confuse. This uncertainty has a more essential and insurmountable nature. In our view, it shall only be addressed when formal methods admitting at least weak inconsistencies are developed, possibly resorting to the use of multivariate logic.

Such methodological development may require more resources and time than those available in studies to support policy decisions. However, a mitigation Study should be aimed at searching at least robust solutions, i.e. those that are attractive even in contrasting contexts.

1.3   Recognising the economic agents and their influence on the system

Even if the two above-mentioned problems were overcome, the solution would reflect only the preferences of the single decision-maker that actively participated in clarifying his decision-making criteria and structure of preferences. One should wonder whether the set of economic and social agents in charge of implementing the chosen mitigation measures will agree to such choices, and if not, whether the political decision-maker shall be in a position to "impose" his preferences.

Given the prevailing institutional arrangement in Argentina, the methodological approach should capture the eventual conflict of interests that arises when other players are included in the analysis. In spite of such need, the ambition cannot be to represent the collective decision making process. Firstly, because no mechanisms exist to channel various economic agents' participation in the decision making process under the terms assumed by the methods to represent collective decisions[41]. Secondly, because the search for consensus involves a bargaining process which each party approaches (or should approach) knowing both his desired solutions and the acceptable limits to bargaining.

Consequently, accepting the existence of other economic and social agents would help identify the impact of mitigation measures on such agents and, according to their magnitude, perceive the feasibility of such measures' implementation. As considering their feasibility involves analysing mitigation actions together with implementation instruments, the most attractive agents for this analysis are those parties having more influence on the system's evolution and more power to affect the selected mitigation options' effectiveness.

Such options' implementation may encounter different kinds of barriers: lack of information, different evaluation perspectives by agents in charge of adopting them, etc. In most cases the political powers' direct intervention will be required, through different political instruments, to modify the economic agents' behaviour. Effective instruments to eliminate such barriers are linked to the different mitigation options' feasibility.

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[41]   Such methods assume objectives and information transparency, which real processes are far from reaching, even in participative decision making processes.

In addition, implementing mitigation options will no doubt involve some cost for the society (*intervention cost)*, as mentioned in the GEF Operational Strategy even if few details on how to compute them are provided in this document. Consequently, and in order not to overestimate certain policies' effectiveness, special attention should be paid when calculating the effective mitigation cost curve.

2 Approach suggested for analysing mitigation policies in Argentina

From the methodological guidelines, mitigation studies seem to aim at selecting a certain number of projects with a potential to mitigate climate change. Even the construction of incremental cost curves is generally presented as a natural ranking of such options as a function of their specific incremental cost. Such approach, albeit suitable for those responsible for implementing mitigation actions, has an extremely restricted scope to design and assess mitigation policies. From public perspective one should choose what to promote and through which mechanisms, so as to encourage or change the prevailing behaviours of economic agents.

Such economic agents' decisions are influenced by a number of factors, amongst which public policies are just a few. Regarding energy technologies and practices, at least as important as policies are the reciprocal impacts between the suppliers' strategies and their customers' preferences.

In the specific case of Argentina, natural gas is gaining a growing importance as primary energy source. Its availability and price in the future will be key for both its penetration in the transport sector and the technology chosen for power generation. Gas distributors' strategy seems to be to promote counter-seasonal consumption, openly competing with electricity in uses such as cold air conditioning. It is clear that this gas companies' expansive strategy will impact their potential customers, but will also be conditioned by the decisions of oil companies in charge of expanding reserves and work natural gas fields.

Such type of interactions within energy supply and between energy supply and demand can be addressed only through a systemic approach. Therefore, the assessment of mitigation policies and their implementation would call for a comprehensive analysis of the whole energy system, so as to address the multilinks between energy supply and demand.

This systemic approach, however, is not an obstacle to search for mitigation options only in the activities having the highest mitigation potential. Preliminary studies carried out in the country on GHG emission show that the *transport* sector and the *manufacturing industry* largely contribute to such emissions. Electricity generation will also play a role in the future if private investors maintain their current technological preferences, thus increasing power plants' GHG emissions.

As electricity generators' technological choice will be conditioned, to a large extent, by other energy companies' strategy, all the energy industries should be analysed, involving all the activities related to energy production and supply in the country.

Energy suppliers' strategy on both supplying expansion and marketing, shall also condition energy consuming sectors' behaviours, broadening or limiting their options.

A detailed analysis of the energy systems operation when mitigation technologies and practices are adopted by final consumption sectors and energy industries would allow for measuring the impacts of mitigation efforts made in those activities on all energy industries.

Regarding methodology, the way to address two of the three problems raised in Section 1 above shall be discussed here: multicriteria decision-making and recognising the economic agents involved. To broadly consider uncertainty would require deep methodological research on methods based on formal structures allowing for weak contradictions in the decision making processes, a research which, as previously stated, exceeds the scope of the present study.

On the contrary, uncertainty on future values of some relevant factors that go beyond national decision makers can be address using the contrasted scenarios technique, searching robust policies which yield satisfactory results when addressing this type of problems, that could be labelled as "lack of accurate information" about the future.

2.1   Economic and social agents

As already said, as from the economy restructuring and public companies' privatisation in Argentina the management of sectors and activities largely responsible for GHG emissions lies exclusively in the hands of private agents. Such agents' decisions will define the evolution of energy demand and supply in the country, and therefore, its contribution to GHG emission.

In the absence of explicit State intervention to promote climate change mitigation, a full understanding of their strategies is essential to formulate the *baseline scenario.* At the same time the success in implementing mitigation actions shall depend on choosing adequate policy instruments to promote changes in economic and social agents' behaviours.

In this context, one should distinguish between the mitigation potential and the effective contribution of each mitigation option when economic agents with greater decision power are in a position to oppose their implementation or transfer to other social and economic agents the eventual damages such policies could cause. Of course, the economic agents' effective capability to sustain their opposition and/or defend their interests vis-à-vis certain public policies depend on power relations between the public and private sectors and the specific characteristics of State regulation over economic activities throughout its territory.

Regardless of such power relations and intervention possibilities provided by regulations to the public powers to influence the energy system's evolution, it is clear that not all economic and social agents have equal influence on the energy system's development and, as a result, on GHG emission's future evolution.

The distinction between agents' categories transversely intersects both the energy supply and demand activities. Among the innumerable energy customers, some large industrial users could alter certain sources' demand growth rate by modifying the technology or enhancing the energy efficiency. Similarly, the automotive industry and transportation companies' decisions could alter the structure of transportation demand and, consequently, the sector's energy consumption. On the contrary, most consumers have a more passive nature acting as price takers in the energy markets, even when they may produce a potentially important impact through a large number of individual decisions.

A similar situation arises in energy supply industries. Although energy supply will result from a number of decisions made by different companies, strategies defined by some of them may condition the remaining ones' decisions, as a result of the strong inter-relation between energy industries.

In order to grasp the scope of this "dominion" suffice it to mention the relevance of oil companies attitude relative to natural gas reserves' expansion and production, for the entire Argentine energy system. A strategy to keep oil companies active in this field would guaranty

278

the trend towards growing use of gas both in end-use sectors and for electricity generation, in favour of broad supply at relatively low prices. On the contrary, low investments in gas exploration together with an excessively aggressive gas exporting policy could become a true barrier to the increase of compressed natural gas use for transportation and prevent independent electricity generators from entering the market, affecting the normal development of such markets and GHG emission.

Based on the above mentioned considerations, the economic and social agents taking part in the energy system can be classified in the following categories:

1. *public agents*, whose behaviour should theoretically adjust to, and in turn favour, the implementation of official policies;

2. *dominant private agents*, characterised by the clear relevance of their decisions on the energy system's evolution;

3. the *quasi-passive private agents*, whose behaviour is strongly conditioned by dominant agents' decisions and the policies in place.

As made clear before, each scenario will make a different use of this distinction between economic and social agents. In the *baseline scenario* dominant private agents' strategy shall define the expected energy supply evolution and in turn condition, via availability and prices, demand's behaviour. In the *mitigation scenario*, on the contrary, one would want to analyse the reaction of dominant agents to different policies and instruments to promote GHG emission abatement.

2.2   The decision making criteria

Regarding decision-making criteria, marked differences also exist between both scenarios. As previously stated, in the *baseline scenario* dominant private agents shall define the energy system's essential trends, thus conditioning the remaining players' behaviour.

Since companies are focused around their own business, their standpoint to analyse the system's development is quite different from that of public powers, regardless of their businesses' diversity in energy production chains. Consumers are perceived in terms of customers, i.e. as a function of their purchasing power. Therefore, the impacts on certain social agents are beyond the companies' interest when defining their business strategies. Sometimes, oligopoly markets induce them to prioritise market acquisition vis-à-vis the short-term economic profit, while their investment strategies go beyond the borders of Argentina. Some investors are evidencing growing interest in internationalising their business, particularly in Latin America, as a result of the regulatory and institutional reforming furthered by most of the countries in the Region.

Therefore, to formulate the *baseline scenario* the strategies of dominant agents could be estimated directly from their behaviours in the last years, without clarifying the decision-making criteria or a detailed simulation of the decision process itself. However, given the long-term scope of mitigation studies, the long-term sustainability of such behaviours should be analysed, particularly regarding reserves' availability so as to detect eventual bottlenecks that might force them to reformulate their strategies.

Opposing this "private" view, the *mitigation scenario* represents the desirable evolution of energy consumption and supply from the public perspective, considering both the role of energy in the economic and social development and its environmental impact. Therefore, in this section we

will discuss how to assess mitigation policies from a public perspective to formulate the *mitigation scenario.* That is, how to select technological and/or practices options to abate the energy system's GHG emission at reasonable cost and with an acceptable impact on the economic and social development.

Firstly, it seems appropriate to know the margins within which GHG emission may vary. The upper limit would be no intervention, represented by the *baseline scenario.* The lower limit could be reached implementing the most effective mitigation options, in terms of their contribution to GHG emission abatement, in each of the sectors analysed, resorting to technologies likely to become available in the next 30 years.

As for technologies, it is important to bear in mind that the *baseline scenario* also assumes certain new technologies' penetration. In such sense, technological differences between the *mitigation* and *baseline scenarios* should not be overstated. *mitigation scenario* should explore mechanisms to promote technological innovation faster than it would naturally occur in coming decades.

In Argentina, the opening up of the economy and the growing competitive environment will surely speed up technologic renovation, at least as regards tradable goods' production and in those sectors most exposed to competition. Therefore, the socio-economic scenario should give some hints on the future pace at which certain activities in the country will approach technologies prevailing at international level.

Although the drastic abatement needed to minimise emissions may be unattainable in terms of costs and social and macroeconomic impacts, the country's maximum contribution to climate change mitigation can be estimated. Such information may be valuable to keep expectations on GHG emission abatement within reasonable limits and help close the "ideal" preference structure to the "real" one while seeking for a satisfactory solution to formulate the *mitigation scenario.* Subdividing GHG emission's maximum variation range into intervals, a number of *mitigation scenarios* can be defined, each corresponding to different effort levels to contribute to climate change mitigation.

Regarding decision criteria to formulate each *mitigation scenario,* the role of costs in implementing mitigation options could be recognised as an important —albeit no excluding— decision criterion. Other relevant factors should complement the cost in selecting mitigation policies. Although the selected factors will depend on public perceptions, the following can be mentioned without intending the list to be complete:

1. The resulting prices in the energy markets;
2. The investments required for implementing mitigation options;
3. The financial flow of energy investments;
4. The impacts on net domestic investment;
5. The impacts on foreign accounts;
6. The impacts on employment;
7. The cost of the energy basket for low-income classes.

To help in searching the preferred mitigation actions, a traditional optimisation model could be used. In this context, the above-mentioned factors would be dealt with in a different way than costs. Whenever the optimisation model had only one objective, costs may be the decision-making criteria (*objective*), while the other factors may be measured by *performance functions*

during the optimisation process as a way to control the desirability of the selected options. This is particularly applicable to impacts on the quasi-passive agents in the system, whose magnitude can be bounded while seeking for an acceptable mitigation alternative, as a way to express the decision-maker's preferences.

In addition, the impact of certain mitigation options and implementation tools on the dominant agents should be monitored through *impact functions*. The decision-maker can subjectively assess the feasibility of selected (optimal) mitigation policies depending on the magnitude of such impacts on dominant agents. It is not the case of Argentina, but whenever the decision making process is based on consensus-seeking negotiations, understanding these impacts helps assess the sacrifice by the parties involved and facilitates negotiation and agreements.

A dominant position in the system would permit private agents to react to mitigation policies so that damages were fully transferred to other economic and social agents, thus affecting the desirability of such measures. For instance, private power investors were willing to increase generating capacity, even in the context of some over-capacity. However, such behaviour will persist as long as they can resort to low-capital-intensive business opportunities having high rate of return. For the moment the result has been a progressive retreat from the hydroelectric option and a remarkable increase in GHG emission in spite of burning almost exclusively natural gas.

Reintroducing the hydropower development program could be an attractive mitigation option from the social standpoint, and even economically convenient in a long-term perspective. As this is not the time frame used by dominant agents, the technological choice will only be changed if a strong increase in electricity retail rates is admitted or if substantial capital contributions are made to fund the works. In both cases, the "intervention costs" on the system would directly impact the quasi-passive agents affecting the country's economic activity and certain social classes' quality of life.

This example also shows that an apparent win-win mitigation action can imply much higher costs than those originally estimated if "intervention costs" to near dominant private agents' decisions to public preferences are added.

3 How to use an optimisation model

The way in which the following aspects should be addressed is important for specifying the methodological approach:

1. the representation of the energy system
2. the decision-making process and the *mitigation scenario* design
3. GHG emission recording
4. the construction of incremental costs curves

3.1 The energy system representation

Because of the type of impacts of mitigation policies to be measured, the system representation is a key element. Besides identifying energy consuming and supplying activities, the energy flows associated to each type of agent should also be differentiated, even when dealing with the same energy process.

Such distinction shall be illustrated through power generation as an example. The traditional representation implies identifying electricity generated through various technologies and/or from different energy sources: hydropower, nuclear, steam turbines burning natural gas and heavy petroleum products, combined cycle gas turbines burning natural gas, etc.

However, business opportunities and electricity generators' dynamics depend on their role in the energy system. Some of them have a marginal influence, regarding both the technology choose for generating capacity's expansion and the opportunities to improve the competitiveness. Such generators would be considered as a quasi-passive agent.

The operators of hydropower plants having reservoir are an extreme example of such generators. Actually, their competitiveness in the marketplace is almost independent from their actions, but is highly influenced by the remaining generators' efficiency (caloric consumption and ability to obtain low-price fuel). Under certain conditions, it may also be more valuable for the system to dam up water in the reservoir than discharge it, thus the hydro generator is excluded from the marketplace because of its competitors' greater "competitiveness".

To different extents, most generators running privatised power stations would fall within the quasi-passive category, especially in an oversupply context as at present. The excess of supply pushes selling prices down, clouding the economic profit of investing to improve their thermal efficiency. Such agents' uncertainty is increased by the advent of new suppliers with clear competitive advantages: new high-thermal-efficiency power stations with low capital intensity and reduced fuel cost.

It is true that over-capacity can be a temporary phenomenon, but certainly cyclic. In effect, the more competitive the wholesale electricity market is, the greater the trend towards a permanent supply-demand imbalance, thus producing a totally different behaviour than power planing aimed at adjusting supply to the expected demand growth.

Within this context, generators unable to ensure, or obtain, comparative advantages, end up defining a strategy that adapts to the circumstances forced upon them. This is precisely the salient feature of quasi-passive agents.

On the other end are the dominant agents, whose strategies impose the context on the remaining generators. Under present circumstances, dominant generators are reinforcing the oversupply phenomenon, but they manage to keep their business profitable while displace less competitive generators out of the marketplace. The key to ensure the new power stations' competitiveness is to obtain low-cost fuels, as proven by oil and gas companies' growing share.

Considering that oil companies themselves are in a position to impose the long term operating conditions in the natural gas market (volumes and prices), it is clear that the dominance in energy supply comes from activity diversification over energy chains and the excluding management of the most attractive energy resources.

3.2   Decision making process and mitigation scenario formulation

The first stage to formulate the *mitigation scenario* should be to define the energy consumption and supply technologies and/or practices that are "desirable" to promote. The second stage should be devoted to select the most appropriated mechanisms or policy instruments to induce the adoption of such technologies. As mentioned, mitigation options' cost plays an important —although not excluding— role in such definition.

Firstly, the type of costs to be considered should be accurately defined, either social or private costs (at market prices), as well as the cost of capital. To define public policies, shadow prices are suggested to assess the inputs and production factors. Besides the fact that the private agents in charge of implementing mitigation options shall make their decisions based on market prices, the use of shadow prices is less reliable or clear than directly computing the impacts on such inputs and resources' availability.

Secondly, the search of mitigation options from a public perspective involves a comprehensive view of the system, i.e. total cost should be lowered accepting even some extra costs for certain agents, as long as such higher costs are set-off by savings elsewhere in the system. On the contrary, private agents are especially concern on who will cover these extra costs and are less willing to appreciate costs' offsets between agents.

Such discrepancy between the public and private perspective could lead to over-estimating certain options' convenience and feasibility. In terms of mitigation studies results, especially regarding incremental costs curves' calculation, it might lead to select options that agents will not implement in spite of their environmental and economic convenience.

In this context, defining the value of the discount rate to be used in the optimisation process appears as a critical element. In the specific case of Argentina, private investors in the energy sector have given clear signs of their preference for businesses with a short-term capital recovery. This means that the discount rate applied to assess their investments substantially differs from the cost of capital at international financial markets. The high cost of money at the local financial market, which even affects loans in foreign currencies, is only applied to minor investors (families and small companies) whereas large investments in the energy, industrial and infrastructure fields have access to funding at rates similar to the international market. However, to use private investors' discount rate from the public perspective would result in a short-term oriented analysis, by excessively privileging the first years of the period.

Consequently, it seems convenient to use for cost accounting (*objective function*) a rate closer to the real capital cost when selecting technologies or mitigation options. However, when calculating the impacts on different economic agents' categories (*performance* and *impact functions)* the rate that better adapts to the agents' perspective should be used in order to adequately represent such agents' perception.

As discussed in Section 3.4, this definition of the objective function, even being a cost, is useless to calculate mitigation incremental cost function and could only be used to identify the most attractive mitigation options to promote through the use of proper policy tools.

For each GHG emission abatement target, within the Argentine system's potential mitigation range referred to in Section 2.2, the pertaining *mitigation scenario* formulation involves the following steps:

1. identify the set of mitigation options that minimise the social cost of emission abatement and compute the impacts within the optimisation process;

2. calculate other impacts considered relevant for the definition for the selected technologies,

3. assess the impacts and comparison with the corresponding *baseline* values;

4. judgement of value about the desirability and/or acceptability of the quantified impacts. When the solution is unsatisfactory, lower and/or upper limits on the performance and

impact functions considered in the optimisation process should be defined to guide the search for a more satisfactory solution;

5. start an iterative process, repeating the four previous steps until a satisfactory solution is reached, i.e. identifying mitigation options to be promoted in order to achieve the established goal for GHG emission abatement;

6. analysis of different policy tools for implementing the mitigation options chosen and recalculating impacts to verify their effects on the different agent categories. In cases in which all policy tools cause unacceptable impacts on certain agents, those mitigation options having the most negative impact should be identified and removed from the pre-selected list;

7. detailed analysis of other impacts not incorporated to the optimisation process.

3.3   GHG emission

The optimisation model used for this analysis should be prepared to compute different types of emission from energy consumption and supply, using some coefficients contained in an environmental database. The model's calibration for representing the Argentine energy system should include the adaptation of such database to guarantee that emissions computed by the model reasonably agree with the emissions reported in the inventory for 1990 and 1994.

As cost discounting in the optimisation process will tend to select mitigation options as late as possible, some limits on emissions must be specified for each year along the period under analysis. To that end, growing savings along the whole period could be defined representing growing mitigation efforts until achieving the target saving in the horizon year.

To define savings' time profile seems more appropriate than discounting future emission flow, as it prevents masking the true size of GHG emission.

3.4   The construction of mitigation incremental cost curves

To use an optimisation model to formulate the *mitigation scenario* is, in theory, the proper mechanism to calculate marginal incremental costs to abate an additional unit of GHG emission, represented by the dual variable associated to emission constraint. However, a number of clarifications are required about such values' meaning and their validity range.

Firstly, the dual variables' values are time-dependant. In that respect it should be noted that the optimisation model computes just one numeric value for costs representing the discounted costs over the whole period, whereas GHG emission (like energy flows and investments in capacity expansion) are independently defined for each sub-period or "milestone year". In a typical five-year-subperiod representation, at least 5 from the 6 milestone years needed to analyse a 25 year period would have a constrain representing the limit imposed on that year GHG emission. Consequently, at least 5 dual variables would exist, representing each of them the impact of emitting an additional GHG unit in the corresponding milestone year on the present value of the costs over the whole period.

Clearly, marginal costs shall substantially differ for each milestone year, not only because it is logic to assume that natural evolution will move towards a progressive decrease in price of more efficient technologies, but also because of costs discounting. Therefore, if marginal costs were to be calculated, independent curves would have to be constructed for all, or at least some, of the milestone years.

284

Secondly, the validity range of this marginal costs should be borne in mind, i.e. costs variation given by the dual variable is, mathematically, a derivative, and therefore reflects the impact of marginal emission variation (infinitesimal). It is true that the sensitivity analysis of every linear programming code provides, together with the marginal cost, the emission variation range within which such marginal cost is still valid. When validity ranges are too small, the model will have to be run an infinite number of times to construct a continuous marginal cost curve covering a reasonable GHG emission variation range.

Thirdly, the value of the dual variable in the optimum solution is absolutely dependent on the objective function, as mathematically it is its partial derivative relative to the limitation imposed on GHG emission. Consequently, the marginal cost shall be valid as long as the cost function (the optimisation objective) reflects mitigation options' effective costs.

As mentioned, the discrepancy between private and social costs could also weaken the meaning of marginal costs given by the optimisation process. Although social costs may be used as guidelines to make a first selection of the mitigation options to be promoted by public policies, the optimisation process itself will be largely conditioned by the assessment of private impacts on different economic and social agents' categories. Such effects, however, are not automatically incorporated to the objective function and, therefore, would not be considered in the marginal costs resulting from the optimisation process.

Having made these considerations, the automatic use of marginal costs to construct mitigation incremental cost curves is not deemed appropriate, although such specific values may be analysed and presented.

Given the importance of the mitigation incremental cost curves in these type of studies, the method to build such curves should ensure that all the damages suffered by either the society as a whole or some of its members for implementing mitigation policies are properly considered.

As part of the model representation, it would be possible to define a new variable to measure the *impact* of selected mitigation options in terms of their specific total costs. The value of this variable in the optimum solution for each GHG emission target level, would be the basis to calculate specific incremental costs relative to the *baseline scenario*. Plotting its values for different GHG emission levels, the specific incremental mitigation costs curve would be obtained.

This way of computing the cost curve does not allow identify each mitigation option's contribution, although such identification shall be easier when the ceiling values imposed on GHG emission are closer.

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