The Meaning of a *Dynamic* Target of Greenhouse Gases Emissions Reduction: the Case of Argentina

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and

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The objective of this paper is to analyse the implications for developing countries to adopt greenhouse gases emissions reduction targets on the basis of a Carbon Intensity Index (Emissions/GDP). The basis for that prescription is that the target becomes *dynamic*, avoiding the slowing down of the countries' development and the creation of "hot air" (since greater growth means greater emissions allowed and viceversa). This paper studies –taking into consideration the case of Argentina-, the advantages and disadvantages of different types of targets (including the above mentioned one) and describes the index chosen by the Argentine authorities to define their target, which is based not on the GDP but on the Root of GDP. The mentioned indicator goes a step forward by causing –for the chosen level of reduction- a *dynamic* reflected in a positive relation between GDP and allowed emissions, but also in a relation of the same sign between GDP and emissions reductions.

[*] The authors thanks the numerous comments made by Jorge Lozanoff to an earlier version of this paper and the valuable contributions made by Fabián Gaioli (in particular to Section II. 4. of this paper). Correspondence should be addressed to: mcg@cema.edu.ar or Universidad del CEMA, Córdoba 374, 1054 Buenos Aires (CF), Argentina. An earlier version of this document (in Spanish) appeared as Documento de Trabajo No.160, Universidad del CEMA, in December 1999.

I. Introduction

The fact that Argentina has announced a target of greenhouse gases emissions reduction at the Fifth Conference of Parties (COP) of the United Nations Framework Convention on Climate Change (UNFCCC) has been an innovative event in the context of world debate on policies for fighting the “greenhouse effect”, since it is the only developing country making a decision of this sort.

But this decision is not directed only to improve the world environment. The advantages foreseen for the country are basically two. The first consists in safeguarding the Kyoto Protocol, which establishes different percentage reductions for the period 2008-2012 with respect to the emissions of 1990 in developed countries and in those with economies in transition –Annex B countries-. This could be a way to avoid a reopening of negotiations that could leave the country in a worse position than it is now. The second advantage is that the Argentinean proposal conditioned the adoption of the target to the access to *all* the mechanisms of the Kyoto Protocol (KP)[1]. The only available instrument for Argentina as a non-Annex B country is the Clean Development Mechanism (CDM), which does not explicitly include capture of carbon through sinks –such as forests-, which constitutes an important part of Argentina´s “potential mitigation”. Thus, access to the mechanism of Joint Implementation (JI) would permit receiving flows of investment to capture greenhouse gases (GHG), with the additional advantage of not having to report to any Executive Board like the one of the CDM. In addition, pure local business investments directed to sinks or GHG mitigation projects could be carried out (and those emissions credits could be traded under the Emissions Trading mechanism -ET-), avoiding “transaction costs” due to negotiations with foreign companies (as is in CDM and JI).

[1] Two “project based” mechanisms exist in the KP. This means that their use requires agreements between companies, where one (or several) of them invest in projects of companies from another country and in return receive all or part of the emissions reductions that result from those projects. In other words, if a country chooses not to restrict its domestic emissions so much because of the high economic costs this implies, it may invest for the reduction of emissions in some other country (with lower costs) and use these reductions as credits in order to comply with their own emission limits. The main advantage of this mechanism is that the compliance with emissions´ reductions of the KP is cheaper (and the countries where the reductions take place benefit through investments): 1) “Joint Implementation” (JI): among Annex B parties (art. 3 of KP) and 2) “Clean Development Mechanism” (CDM): among Annex B and non-Annex B parties, does not include sewers and is controlled through an international administrative structure 8art. 12 of KP). Finally, a third mechanism of “Emissions Trading” (ET) is established in the KP, which is only for Annex B countries (art. 17 of KP).

Nevertheless, assuming this target can also have impacts at the international level, helping to untie the KP entry into force. This is due to the fact that though none of the parties of the UNFCCC has the power to veto, some few large Annex B countries are in a position of not ratifying the KP if developing countries do not assume some type of reasonable quantitative commitment[2]. The basis of this intention is that though according to the UNFCCC, “common but differentiated” responsibilities should be recognised, it is also true that, if the developing world continues contaminating at a growing rate, even though developed countries fulfil their commitments, GHG world emissions will continue to increase[3]. The announcement of Argentina’s target, if followed by other no-Annex B countries, offers the possibility for a loosening of the conflict, and the KP could be in force with the consequent benefits for the global environment.

II. Methodology for the Definition of the Target

In 1999 the former Secretariat of Natural Resources and Sustainable Development developed a series of tasks to define the target, which was announced during the COP5. The assumed commitment aims at reducing the growth rate of the emissions below what it would have been if this had not existed, that is to say, below the future scenario called “Business-as-Usual” (BAU). The target was fixed with respect to the average of the period 2008-2012, in order to be comparable with the period of commitment that the countries Annex B have in the Kyoto Protocol (2008-2012).

As happens generally in all countries, the GHG in Argentina are strongly linked with the activities that emit those gases. These activity levels, in turn, maintain a close relation with the country’s macroeconomic reality. Therefore, the determination of a target requires fulfilling four steps:

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[2] According to its art. 25, the KP will enter into force when 55 countries ratify it, if these include countries of Annex B representing no less than 55% of the CO_2 emissions in 1990. This percentage was chosen sufficiently high as to ensure certain consensus, but not so high as to enable big countries, as for example the United States (36% of the developed countries’ carbon and 23% of the world) to have veto power with their not signing of the Protocol.

[3] According to Energy Information Administration (1998), if they continue with their tendency, the emissions of the non-Annex I countries of the UNFCCC (almost the same as the non-Annex B of KP) would surpass those of the Annex I countries (almost the same as those of Annex B of KP) between the years 2015 y 2020.

1. Have a detailed knowledge of past and present emissions of GHG by type of gas and source, in order to know where we stand and have foundations to make prospective analysis;
2. Project BAU scenarios as reference of the emissions that would be generated if no mitigating measures were adopted;
3. Consider possible mitigating actions to calibrate the feasible level the target may have; and finally,
4. Based on the former, considering what *type* of target to adopt, and also its *level*.

These are the motives due to which the work for determining the target was based fundamentally on four central lines:

1. GHG inventory based on 1997 (the first National Communication of Argentina to the UNFCCC contained the inventory to 1990 and 1994, which were also revised and updated);
2. Projections of GHG emissions up to the year 2012:
    i. Macroeconomic projections
    ii. Sectoral projections;
3. Possible mitigation measures (with their respective costs); and
4. Definition of the type of target and its level.

The used methodologies and the results obtained at each step are described briefly below (more details with respect to the first three points can be found in SRNyDS 1999a and SRNyDS 1999b).

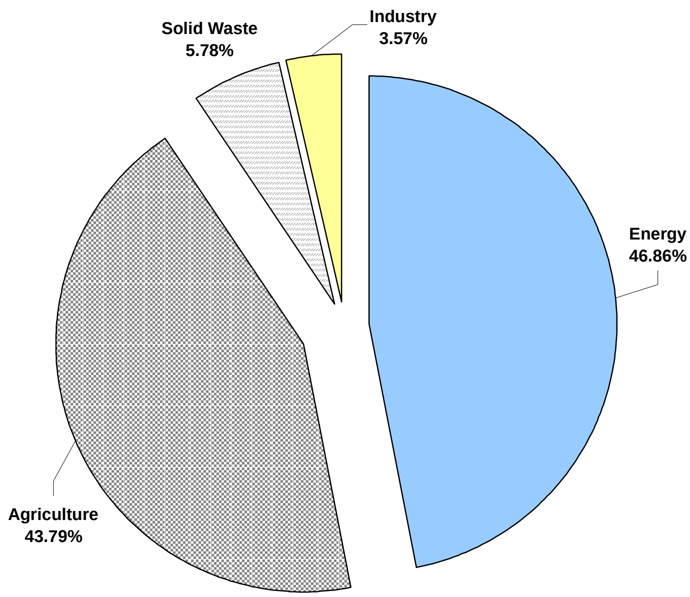
1. Inventory of GHG Emissions 1990, 1994 and 1997

The methodology used to make the 1997 inventory is that of IPCC (Intergovernmental Panel of Climatic Change)[4]. In general, it can be said that:

a) In 1997, total emissions of GHG in Argentina represented 76.8 million tons of Carbon equivalent (MTCE). This implies that the emissions intensity index (Emissions/Gross Domestic Product) was 0.28 (expressed in tons/1000 $ of 1993)[5].

[4] The last revision of 1996 was used: IPCC(1997).

Figure 1. Participation of each sector in total GHG emissions: 1997 Inventory



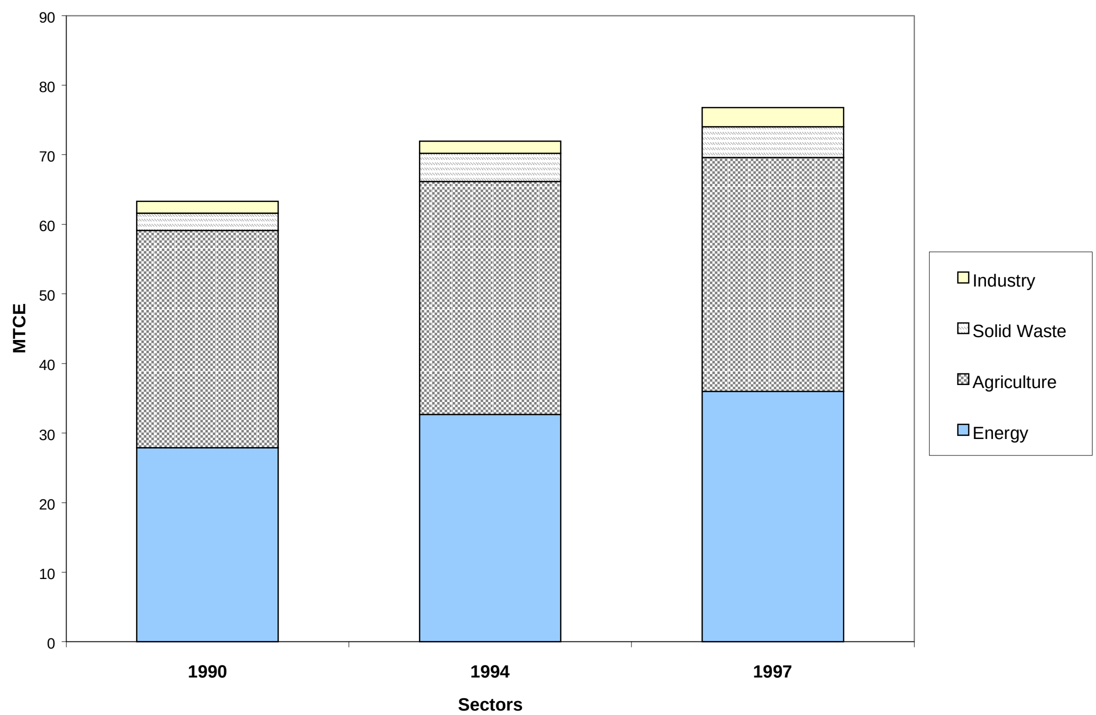
b) As to the participation of productive sectors in the total emissions, the 1997 inventory shows that the energy sector and agriculture sector represent jointly 91% of GHG emissions (figure 1) while the rest of the emissions come from industry (3%) and wastes generation (6%). It also seems important to note that within the agriculture sector approximately 75% of the emissions come from cattle raising.

c) As to the evolution in time, total emissions have increased 21% between 1990 and 1997, and 7% between 1994 and 1997. However, this has been accompanied by a decrease in the index of emission intensity from 0.35 in 1990 to 0.28 in 1997. As to the relative participation of each sector in the total, the energy and waste sectors increased while the agriculture sector decreased (figure 2). More precisely, each one

[5] This number differs from the one reported by Baumert, Bhandari and Kete (1999) and Center for Clean Air Policy (1998) for Argentina because it contains all the emissions (not only those of energy sector) but also because here GDP is not measured in dollars according to the “Purchasing Power Parity” or the market exchange rate.

of them passes from representing 46%, 4% and 47% in 1990 to contributing in 50%, 6%, and 41% of the emissions in 1997[6].

Figure 2. Evolution of GHG emissions based on Inventories



In addition, the inventories of 1990 and 1994 were reviewed to incorporate basically:

a) The emissions of N_2O in the agriculture sector;
b) Better estimation of the fugitive emissions of natural gas in the systems of production, transport and distribution of carbohydrates:
c) Changes in the cattle raising sector's emissions through differences in the index of digestibility used for the enteric fermentation of animals.

These adjustments constitute an increase of around 41% of the total emissions computed in 1990 and in 1994[7].

[6] Note that these numbers incorporate within the energy sector, energy related emissions generated by the agriculture sector. If not, participation of energy, waste, and farming sector go from 44, 4 and 49% in 1990 to 47, 6, and 44% in 1997 respectively.

2. Projections of GHG emissions to year 2012

As was mentioned above, emissions depend to a great measure on the evolution of the economy (this is the case of the energy sector, industry and waste management, at least in Argentina). For this reason, the first step in their projections consists in making a prospective analysis of the expected evolution of Argentine economy up to 2012.

i. Macroeconomic projections

Due to the great uncertainty that is implicit in the projections of the economic evolution of a developing country like Argentina, three scenarios were calculated: a middle scenario and two alternative ones: one low and the other high[8]. Three renowned centres for projections on Argentine economy were responsible for this work. The centres that were chosen were the Facultad Latinoamericana de Ciencias Sociales (FLACSO), the Fundación de Investigaciones Económicas Latinoamericanas (FIEL), and the Universidad del CEMA[9].

In order to achieve the same objective, each one of them used what they considered an adequate methodology. This helped to reach the desired result as to the diversity. For example, CEMA made a "bottom-up" analysis based on the evolution of sectoral GDP in order to project the aggregate GDP, while FLACSO chose the opposite method, projecting GDP on the basis of basic macroeconomic equality (PBI = Consumption + Investment + Exports - Imports) and, once obtained, deduce each sector GDP. Although a model of computable general balance for the economy does not exist for Argentina, each work was based, in a way or another, on a consistent scheme of equations that in a simple manner approximates a scheme of that type. In every case,

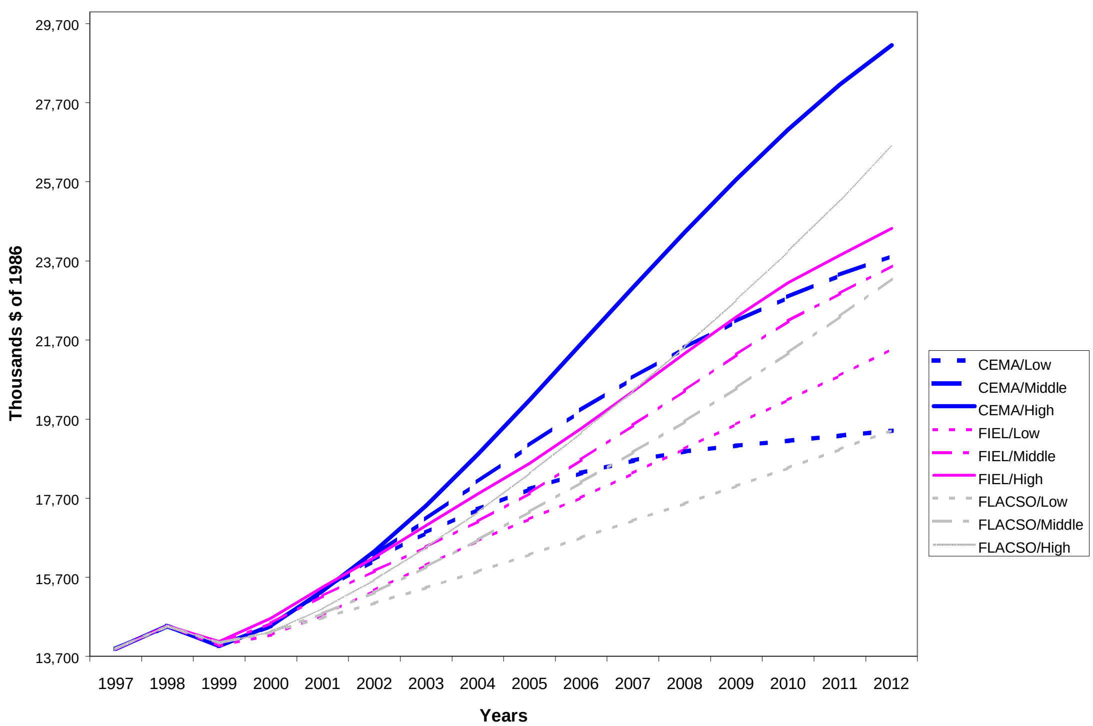
[7] Most of this difference is due to the absence of N_2O farming emissions reporting in the First National Communication.

[8] An analysis was also requested from Fundación Mediterránea. Their projections yield relatively lower GDP growth rates than those of the other three foundations (LowGDP=1%, MiddleGDP=2.5%, HighGDP=3.9% for the 1997-2012 period). But, having been submitted after the established date, the low scenario was not incorporated as the lowest one in the sample of 16 projections in the final calculations.

[9] The macroeconomic projections included different descriptive variables of evolution of the international economy, basically: rates of growth of the GDP for countries with which Argentina maintains relations, prices, exchange rate and international interest rates. As to Argentine economy, the 5 types of indicators were considered: 1) GDP total and per cápita at market prices, 2) Macroeconomic aggregates: Consumption, Investment, Exports and Imports, 3)

the key coefficients were estimated econometrically. Then, the different scenarios were projected on the basis of different hypothesis of the evolution of the exogenous variables in each case.

Figure 3. Projected GDP: 1997-2012



The results obtained in this way offered a rank of possible evolutions (in all cases projected annually) of Argentina´s economy from 1997 to 2012. Figure 3 shows the little dispersion between the middle scenarios, whose average rate of GDP growth (1998-2012) is as similar as 3.7% for CEMA, 3.6% for FIEL and 3.5% for FLACSO. To the aims of the target, the one considered as the middle scenario was the scenario of FIEL (3.6% of the average GDP growth). The lower scenario was the CEMA one, with an average GDP growth of 2.3% (practically the same as the lower of FLACSO), and the highest was also the scenario of CEMA, with a 5.1% average GDP growth. These three scenarios (low, middle and high) constituted, together with the sectoral studies mentioned below, the base for the projection of the "Business-As-Usual" (BAU) scenario for the determination of the target[10].

Sectoral GDP (at 1 ore more digits of the Clasificación Industrial Internacional Uniforme, CIIU), 4) International relevant prices, Exchange rate, Interest rates and 5) Evolution of labor market.

[10] Macroeconomic projections were shown in thousands of 1986 $, as that was the basis of national accounts at the time of the investigation. However, new data (expressed in millions of 1993 $) was communicated by the

The scenarios of maximum and minimum growth imply growth rates that, though not very probable, are still possible if one takes into consideration that in the last two decades Argentine economy has passed first through a long period of stagnation, which was followed by one of sustained expansion. Therefore, this opening of potential rates of growth is important in order to make serious projections of a developing country like Argentina, in which there have been abrupt changes in the fundamentals of the economy.

ii. Sectoral Projections

As was mentioned above, from the inventories of GHG emissions can be seen that emissions originate basically in the energy sector (including transportation), and in the agriculture sector (fundamentally cattle raising). An additional dimension exists (in terms of GHG capture) which is the forestry sector, with great potential for Argentina. In consequence, the more detailed sectoral analyses were restricted to the sectors of energy, agriculture and forestry. With less detail, due in part to its lower complexity, was considered the sector of waste management. The same was done for industry, because it represents a small percentage of emissions[11].

Table 1 summarises the results of the sectoral projections of emissions. In each case, the methodology used was the following:

a) *In the energy sector,* the work was performed by Fundación Bariloche. They used LEAP (Long-range Energy Alternatives Planning System), a simulation model developed by the Stockholm Environment Institute (Boston Center at the Tellus Institute). Both the macroeconomic projections and the projections on reserves and exports of the Energy Secretariat were taken into consideration. In all the cases, the BAU scenarios contemplate an increase of the efficiency resulting from the incorporation of more adequate technology, as a result of the allocation made by the market. Thus, in the case of electric energy generation, it is assumed that the new equipment of generation or the replacements of the obsolete ones, will be fundamentally based on natural gas with a combined cycle. On the other side, the

authorities in September 1999. Therefore, being the target for the future, a subsequent adjustment was made of the projections based on the average difference between 1993 and 1997 between both series as to express the target with the new base of Argentina's national accounts.

[11] There was also a projection of future HFCs emissions available from surveys in the private sector.

greater efficiency that is expected in the residential and commercial energy consumption, as in the transportation sector, is included in the BAU scenario and not as a mitigation option, following the criteria of calculating the BAU as a scenario of "dynamic frozen efficiency". This implies considering the incorporation of technology that, it is already known at the present time, that it will take place.

b) *In the agriculture sector*, the work was done by CENIT (Centro de Investigaciones para la Transformación). A OECD model adapted to Argentina (AGLINK-Argentina) was used for this sector projections. This model uses, as external variables, the agriculture prices and the yields or levels of efficiency of the production systems for projecting the sector's production levels[12]. This sector presents little elasticity with respect to macroeconomic development since its evolution depends mainly on external prices and conditions. Cattle raising is that of greatest weight in its emissions. There are encountered opinions concerning the future of livestock in Argentina, due to the new condition of country free from foot-and-mouth disease, being difficult its future projection. Therefore, in order to be able to count with results permitting an evaluation of the uncertainty of future emissions in the sector, three scenarios were developed. One considered as the most probable and two others with maximum and minimum livestock development, determined by possible extreme prices of live animals. Given the importance that the agriculture sector has in the GHG emissions of Argentina, it is clear that its different possible scenarios add an additional factor of uncertainty on the future GHG emissions.

c) *In the forestry sector*: For the implanted species, a statistic model (done by Varela and Asociados) was used. It deals with the equilibrium between supply and demand at the regional level, because the costs of freight to the industrial demand must be placed in each particular region. The level of demand was determined by means of surveys on present and future investments, obtained in the business sector. Here also, there is much uncertainty concerning the future evolution, since the fiscal deficit can jeopardise the level of subsidies (very important for the development of the sector,

[12] The model allows to simulate the competition between agriculture and cattle raising for space, thus although emissions are greater in the scenarios with high prices for cattle, there exists a compensation for the lower emissions of agriculture.

through the "Ley de Inversiones para Bosques Cultivados" 25.080 of 1998), affecting future plantations.

d) *In the solid waste sector:* a regression model was used, based on GDP per capita and on waste information from CEAMSE (Coordinación Ecológica Area Metropolitana Sociedad del Estado) and other organisms in charge of the disposal of solid waste.

e) *In the industry sector:* the emissions of cement and the iron and steel sector were extrapolated on the basis of macroeconomic projections.

Table 1. GHG Emissions by sectors (MTCE): BAU

				Low Scenario			Middle Scenario			High Scenario		
	1990	**1994**	**1997**	**2008**	**2012**	**Prom.**	**2008**	**2012**	**Prom.**	**2008**	**2012**	**Prom.**
Energy*	27.9	32.7	36.0	49.1	51.1	50.1	52.9	61.9	57.4	61.9	72.5	67.2
Industry**	1.7	1.8	2.7	2.8	2.9	2.8	3.4	4.6	4.0	3.6	4.4	4.0
Waste	2.5	4.0	4.4	5.9	5.8	5.9	6.5	6.8	6.6	7.1	7.9	7.5
Crops*	4.3	5.7	7.4	11.0	11.6	11.3	9.1	8.9	9.0	10.2	10.2	10.2
Livestock	26.9	27.8	26.2	27.4	23.5	25.4	29.3	27.0	28.2	33.4	33.4	33.4
Total GDP related sectors	*32.1*	*38.5*	*43.2*	*57.8*	*59.9*	*58.8*	*62.8*	*73.3*	*68.0*	*72.6*	*84.8*	*78.7*
Total not GDP related sectors	*31.2*	*33.5*	*33.6*	*38.4*	*35.1*	*36.8*	*38.5*	*35.9*	*37.2*	*43.6*	*43.5*	*43.5*
Total	***63.3***	***72.0***	***76.8***	***96.2***	***95.0***	***95.6***	***101.2***	***109.2***	***105.2***	***116.2***	***128.4***	***122.3***

Notes:
* The Energy sector does not include Energy emissions from the Agriculture sector, which are included under Crops.
** Industry includes HFCs, PFCs and SF6 in 1997.

As a result of the projections it becomes clear that:

a) Without any mitigation measure (in the BAU scenario), Argentina´s total GHG emissions (average for period 2008-2012) will represent 95.6, 105.2, 122.3 MTCE in accordance to the low, middle or high scenarios respectively. In its turn, the index of intensity of emissions might reach values of 0.25, 0.24 and 0.23 respectively.

b) Participation of productive sectors in total emissions will be such that the energy and agriculture sectors would continue to represent together about 90% of GHG emissions, though the energy sector's advance is accompanied by a decline in the agriculture sector (for example, with scenarios of high growth both in the agriculture as in the non-agriculture sectors, energy would begin to contribute with 56.6% of the emissions against the 34% of the agriculture sector).

c) As to the evolution in time, total emissions would grow between 24 and 59% with respect to 1997. However, this would be accompanied by a decrease in the intensity index of the emissions (Emissions/GDP) from 0.28 in 1997 to 0.25, 0.24 and 0.23 in the period 2008-2012 according to the resulting scenarios (in other words: a reduction between 11 and 18%).

3. Possible mitigation measures[13]

Since the 90s, Argentina has been implementing policies based on opening and generally deregulating the economy. Those actions have favoured the mitigation of GHG emissions by means of the incorporation of efficient technology (for example, in the electricity market). More direct policies have also been implemented by means of concrete regulations and subsidies with private or fiscal costs (for example, regulations to reduce fugitive methane emissions in oil production and subsidies for forestry).

Although there exists an ample range of measures for possible mitigation, the selected ones were those that for their magnitude would be the most important, and of these, those of more feasible implementation. Thus, a number of options were analysed in the different sectors:

a) Energy Sector

Production:

- *Hydroelectricity.* Each of the hydroelectric works for which there were available studies permitting an estimation of their mitigation costs has been examined. Most of them have burdensome incremental costs for carbon emissions reductions (since it is valued with respect to its opportunity cost, that is, with reference to the baseline scenario in which energy is produced with natural gas combined cycle equipment). Besides, in many cases there are doubts with respect to the implementation of this sort of measures because there are doubts concerning the environmental impact of these works (typically because of the creation of flooded areas).
- *Wind Energy:* Argentina´s potential capacity to produce wind-energy is equal to several times the total installed capacity for the generation of electric power in the country. Nevertheless, for several reasons, one of which is the cost, the use of this resource is at present very reduced. Nevertheless, there are national and

provincial laws that include fiscal incentives to promote its use. So some additional activity in that sense can be expected, and in this case it should clearly be a mitigation measure induced by a direct policy.

– *Energy Co-generation*: This option offers an important possibility of mitigation in industrial activities with additional benefits derived from fuel savings and from less local contamination.

– *Fugitive emissions:* the Secretariat of Energy has determined that there should be a progressive reduction of natural gas emissions from oil wells. Thus, this is again an example of policies adopted to reduce GHG, which will have an impact in the near future.

Transport (Substitution of energy sources): An analysis was made of the greater penetration of natural gas in transport. More specifically, in private cars, and above all in urban public transport of passengers and in light duty trucks.

b) Agriculture Sector

Crops: The analysis was focused on the possibility to introduce "low till" or even "no till" (commonly known as direct sowing). They can lead to less fuel consumption in agricultural labour. Direct sowing can also have a high positive impact on soil conservation (producing carbon capture).

Livestock: The mitigation measure considered is that of a greater efficiency of the sector by intensification production, with better feeding and an increase of the percentage of animals in feed-lot.

c) *Forestry:* In the case of the forestry sector, Argentina follows active policies with explicit fiscal costs (government subsidies) that are contributing to increase the stock of carbon stored in plantations. There is existing legislation on the matter, that will continue maintaining this policy in the long term. Therefore, the increase of carbon stock in the forest plantations in the period of commitment should be considered as a mitigation option.

c) *Solid Waste Sector:* The methane emissions of the sanitary fillings can be burned avoiding the greenhouse effect of this gas which is much greater than that of carbon

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[13] A study of costs and a detailed quantification of each one of the mitigation options were also made. However, details are not included here for considering they have to do with implementation of the target, which is a domestic

dioxide which takes place in its combustion. Until 1997 sanitary filling was only done with the wastes of the Buenos Aires Metropolitan Area, but this practice could be extended in the near future to at least another six big cities. This implies also a real and cheap possibility of mitigation.

As was mentioned further above, these measures of mitigation do not constitute an exhaustive list and there are other possible actions that can be contemplated. For example: the use of methane emanations from sanitary fillings as power, the substitution between means of transport in favour of those less contaminating in GHG terms, etc. However, the total estimated amount of mitigation possibilities (and their costs) was used as a reference to set the "level" of the proposed target.

4. Definition of the type of target and its level

Given the 1990, 1994 and 1997 inventories, emissions projections under several scenarios, and the knowledge of the most feasible and most important GHG mitigation options, the target can be established.

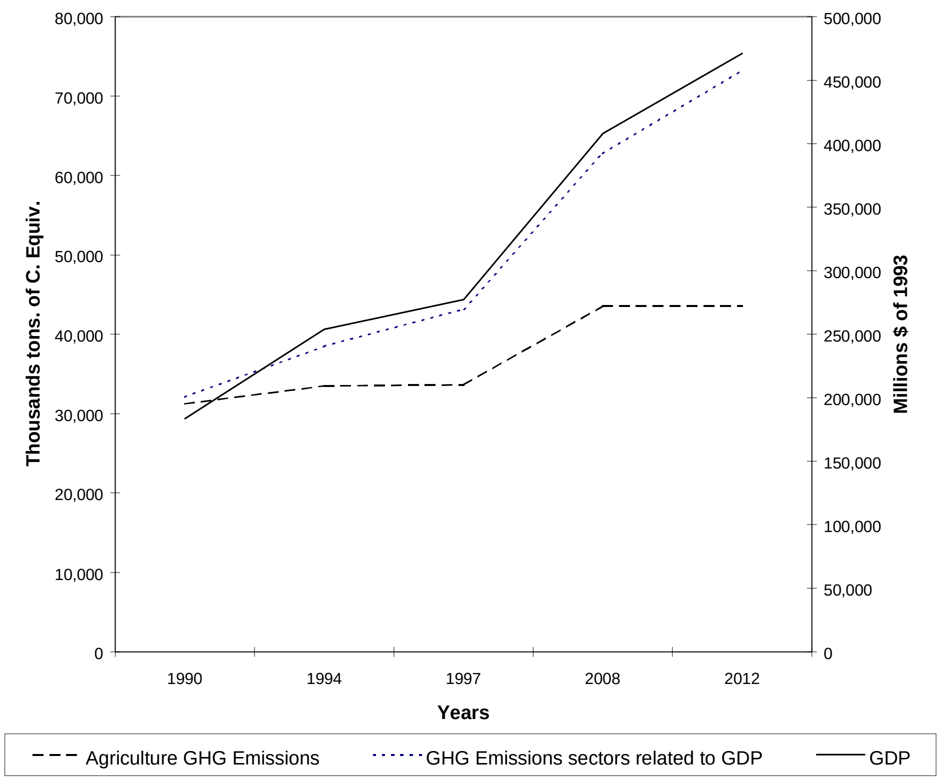
After the work was done it was clearly seen that the GHG emissions in Argentina are strongly linked with the movements in the national economy, with the exception of the agriculture sector. This is in great part because Argentina is a country that is a price-taker (and “conditions-taker") in international markets of crops and livestock products, so the prosperity of this sector depends more on the ups and downs of those markets that on own domestic conditions. This means that it is possible to have years of expansion in the economy with a difficult situation in agriculture, with the consequent impact on emissions (on that matter, see years 94-97 in figure 4).

Therefore, as a first step for determining the target, three scenarios (high, middle and low growth) of the agriculture sector were combined with the three resulting scenarios of the economic sectors sensitive to the GDP (energy, industry and waste management). This way, the 9 scenarios of GHG emissions, cover an ample scope of probable scenarios given the uncertainty of the domestic and international economy (as refers to prices and access conditions for our products). As can be seen in figure 5, the resulting dispersion between the different scenarios is

policy issue not yet defined.

of approximately 27 MTCE of difference between the lowest scenario –Low rel. GDP/Low Agriculture- and the highest –High rel. GDP/High Agriculture- (taking the average for the period 2008-2012), represents 25% of average emissions of the 9 scenarios.

Figure 4. Evolution of GDP and GHG Emissions
(reference scenario: Middle GDP growth and High Agriculture growth)

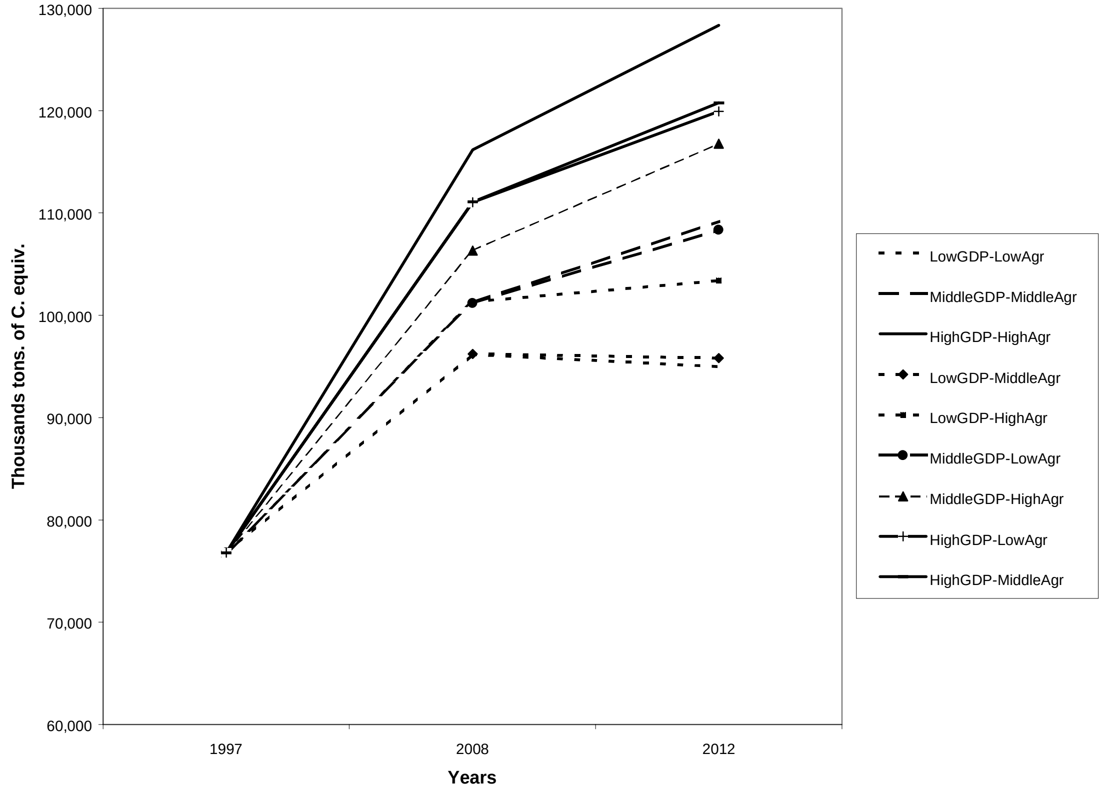


i. Type of target

When searching for the type of target to set, it was important to consider the distinct behaviour of the agriculture sector (as to its little relation with the domestic economy's evolution). But two fundamental factors were also considered: the target does not have to be an obstacle to sustainable development, and the target must be credible in the sense of not creating hot air[14].

[14] A typical example for describing what is known as "hot air" is that of the economies in transition, where the emission reduction for complying with their targets will not be so much the result of voluntary efforts but of the economic crisis that affects it. Therefore, the "excess" of emissions is not more than a mirage due to a depressed economic situation.

Figure 5. Evolution of GHG Emissions in the 9 projected scenarios



In that direction the situation can be simplified, considering that the emissions can be described by the following equation:

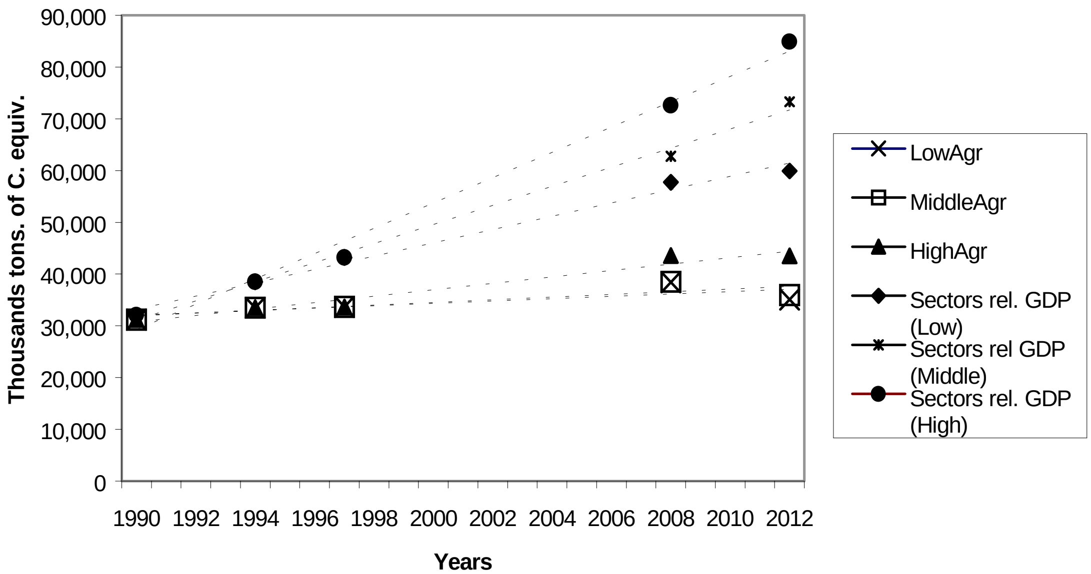
$$E_{BAU}(t) = \alpha \cdot GDP(t) + \beta \cdot A(t) \tag{1}$$

Where $E_{BAU}(t)$ are the real emissions that result in time if no mitigation strategy is adopted, GDP(t) is the gross domestic product which also depends on time, A(t) represents a variable associated to the market situation concerning prices and access of our agriculture products, while α and β are supposed to be constant in time (and between scenarios). In the case of Argentina, figure 6 shows that this equation is a reasonable approximation, though not exact, of the situation, since emissions of the Energy, Industry, and Waste Management sectors seem to be proportional to the GDP. However, the positive relation between GDP and the agriculture sector's emissions is not as clear. More so, it can be said that the agriculture sector's emissions are approximately constant in time. Then, equation (1) can be rewritten as:

$$E_{BAU}(t) \approx \alpha \cdot GDP(t) + c \tag{2}$$

Where c is a constant in time (and between scenarios).

Figure 6. GHG Emissions as a function of time



But, the adoption of a commitment implies reducing emissions. This reduction can be expressed as:

$$RE(t) = E_{BAU}(t) - E_P(t) \tag{3}$$

Where RE(t) is the reduction of emissions or "commitment" and $E_P(t)$ are the permitted (or allowed) emissions to comply with the commitment.

There are several alternative ways to define $E_P(t)$. But, in all the cases, the idea is to achieve $E_P(t) < E_{BAU}(t)$ so as to have $RE(t) > 0$.

a) Alternative 1: Fixed target expressed as an absolute or percentage reduction of the emissions that would be produced if no mitigation measures were undertaken

In the case of expressing the target as an absolute reduction:

$$E_P(t) = E_{BAU}(t) - \theta \tag{4}$$

Where θ is a fixed amount of emissions to reduce (combining (3) and (4), RE(t) = θ). In the case of expressing the target as a percentage reduction, the equation (4) is transformed into:

$$E_P(t) = [1 - \rho] \cdot E_{BAU}(t) \tag{5}$$

Where $0<\rho<1$ is the percentage of reduction looked for (combining (3) and (5), $RE(t) = \rho \cdot E_{BAU}(t)$).

For a fixed target a "reference scenario" must be established, because a target in which allowed emissions depends on $E_{BAU}(t)$ is not easy to monitor since when 2008 arrives mitigation measures will have already happened, hence, it will not be clear what is the "business-as-usual scenario".

For Argentina, this "reference" scenario is that of a middle growth of emissions connected to the GDP and a high growth of those related to the agriculture sector. This is so because no great crises are expected in macroeconomics, and on the other hand it is reasonable to think that as Argentine meat has been declared free from foot-and-mouth disease, it could penetrate some markets that were previously forbidden. Then, for this case, combining the reductions of the emissions that are implicit in (4) and (5), it results that the target can be determined in such a way that:

$$\theta = \rho \cdot E^R_{BAU}(t) \tag{6}$$

where $E^R_{BAU}(t)$ are the emissions of the "reference" scenario.

Thus, from (4), the allowed emissions will emerge for every one of the nine scenarios from:

$$E_P(t) = E^R_{BAU}(t) - \theta \tag{7}$$

This option's advantages would basically be two: that the target would be easy to understand and that it would be expressed in the same way as Annex B countries commitments in the KP, though not with respect to the 1990 emissions but to those expected in the average 2008-2012 without adopting any mitigation measure.

Table 2. Commitment in each one of the projected scenarios under a fixed target

Scenarios	*EBAU(t)*	*EP(t) -ec.(7)-*	*RE(t)-ec.(3)-*	*Effort**
(average 2008-2012)	(Thousands tons. of C. Equiv.)			
LowGDP-LowAgr	95,582	100,405	-4,823	-5%
MiddleGDP-MiddleAgr	105,219	100,405	4,814	5%
HighGDP-HighAgr	122,272	100,405	21,868	18%
LowGDP-MiddleAgr	96,023	100,405	-4,382	-5%
LowGDP-HighAgr	102,365	100,405	1,960	2%
MiddleGDP-LowAgr	104,778	100,405	4,373	4%
MiddleGDP-HighAgr	111,561	100,405	11,156	10%
HighGDP-LowAgr	115,490	100,405	15,085	13%
HighGDP-MiddleAgr	115,931	100,405	15,526	13%

Note: * Effort is calculated as RE(t)*100/EBAU(t).

In the case of Argentina, it was considered adequate -given the mitigation options analysed in section II. 3- to choose a 10% GHG emissions reduction with respect to the BAU reference scenario (θ = 11.16 MTCE). However, even when this target is fulfilled, if there is low GDP growth and agriculture sector grows slowly or average, "hot air" would be generated (see table 2). Besides, with this commitment, the effort to be done would be unequal according to which BAU scenario that finally results. If, for example, the economic scenario were the most pessimistic (low growth of emissions linked to GDP and low growth of emissions of the agriculture sector), there would not be real commitment but, if the scenario were the most optimistic, the required RE would represent 17.9% of E_{BAU}. Therefore, this alternative would have the disadvantage of being risky due to the dispersion existing between the projections of the nine scenarios, and for that motive, would lead to adopting conservative positions so as not to risk the country's economic growth. These disadvantages led to consider a second option:

b) Alternative 2: Dynamic target based on an Emissions Intensity Index

This type of target has been the object of several publications (for example, Baumert, Bhandari and Kete -1999- of the World Resources Institute and Center for Clean Air Policy -1998-). This would be in itself an advantage, being an "expected" target for a developing country and, because of that, easy to accept by the international community.

In formal terms, this would mean that the equation (5) could now be expressed as:

$$E_P(t) = I \cdot GDP(t) \tag{8}$$

where I is a parameter. For the targets to be comparable in terms of permitted emissions, the value of I is defined making equation (8) equal to equation (5) for the scenario of reference and the desired reduction, due to which:

$$I = (1-\rho) \cdot \frac{E^R_{BAU}(t)}{GDP^R(t)} \tag{9}$$

A target of this type would have the advantage -very valuable for a developing country like Argentina (and for all non-Annex B countries)- that to a greater GDP, greater will be $E_P(t)$, the allowed emissions (this is so because from (8): $\frac{\partial E_P(t)}{\partial GDP(t)} = I > 0$). Therefore, it is said that this type of target is "dynamic" because according to the GDP that is really produced in the country the target becomes harder or more lax in terms of the allowed emissions.

Nevertheless, one of the disadvantages of this option is that it does not contemplate the fact that the agriculture sector has an evolution that does not depend strictly on the GDP. Therefore, adopting a target based on this index implies that the commitment -RE(t)- becomes greater when there is less growth (less GDP) and less when there is more development (greater GDP). Translated into equations, combining (2), (3) y (8):

$$RE(t) = (\alpha - I) \cdot GDP(t) + c \tag{10}$$

which implies that $\frac{\partial RE(t)}{\partial GDP(t)} = (\alpha - I) > 0$ only if α > I. Another undesirable characteristic of this type of target is that it can imply that RE(t) < 0 if $\alpha < I - \frac{c}{GDP}$.

The real consequences of a target of this type for the case of Argentina are shown in Table 3 and Figure 7. If the same level of target as before is adopted, the real commitments would involve effective reductions of between 8.4 and 14.5% of the BAU emissions in the scenarios of Low GDP but there would be a "surplus" of between 0.2 and 6.1% of the BAU emissions in the scenarios of High GDP. This target would imply increasing the GHG emissions in the average of 2008-2012 between 14 and 60% with respect to 1997, though the rate of intensity of the corresponding emissions would decrease 17% with respect to 1997 (I=0.23).

Table 3. Commitment in each one of the projected scenarios under an Emissions Intensity Index target

Scenarios	*EBAU(t)*	*EP(t) -ec.(8)-*	*RE(t)-ec.(10)-*	*Effort**
(average 2008-2012)	(miles de ton. de C. equiv.)			
LowGDP-LowAgr	95,582	87,548	8,033	8%
MiddleGDP-MiddleAgr	105,219	100,585	4,635	4%
HighGDP-HighAgr	122,272	122,514	-242	0%
LowGDP-MiddleAgr	96,023	87,548	8,475	9%
LowGDP-HighAgr	102,365	87,548	14,816	14%
MiddleGDP-LowAgr	104,778	100,585	4,194	4%
MiddleGDP-HighAgr	111,561	100,585	10,976	10%
HighGDP-LowAgr	115,490	122,514	-7,025	-6%
HighGDP-MiddleAgr	115,931	122,514	-6,584	-6%

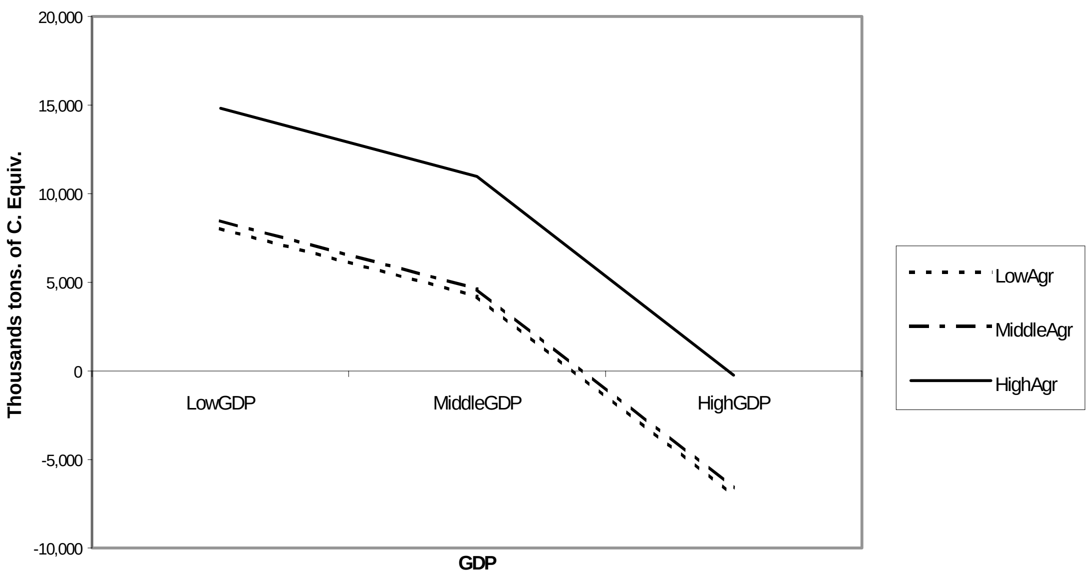
Note: * Effort is calculated as RE(t)*100/EBAU(t).

In addition, for the level of commitment that is wanted, it would be easier to comply with the target if the country grew just a little than if it grew more, to the point that there could be circumstances in which there simply would be no commitment. This is because in this case α > I, since part of the emissions originate in the agriculture sector (c), constitute a "filtration" that reduces the value of α with respect to I[15].

[15] In a rudimentary manner, in order to approximate the value of α, the α implicit in the scenario of reference with the target may be analyzed. Analytically, it may be deduced from combining (2) and (9) that: $\alpha = \frac{I}{0.9} - \frac{c^R(t)}{PBI^R(t)}$. Therefore, the value of α would be approximately 0.06, very inferior to I (=0.23). Another way to implicitly find the value of α is, emulating equation (2), to run a linear regression between Emissions, GDP and a constant with a series of values of emissions and historic GDP (1980-1997). The result of this exercise gives a value of 0.14 for α.

On the other side, in the scenarios of High GDP and Low, Middle or High Agriculture Sector, it seems that $\alpha < I - \frac{c}{GDP}$, and so no commitment is assumed. Because of all this, as an alternative, the modification of the index of emission intensity was considered[16]:

Figure 7. Emissions reductions (RE) for the target set by the Emissions Intensity Index **(-10% with respect to the Middle GDP-HighAgr scenario)**



c) Dynamic target based on an index of Emissions/Square Root of GDP

The reason for the adoption of a modification of the emissions intensity index by an index that, in place of the GDP, uses the square root of GDP, is the fact that the latter empirically describes "better" the evolution of Argentine emissions (in that respect, see figure 8).

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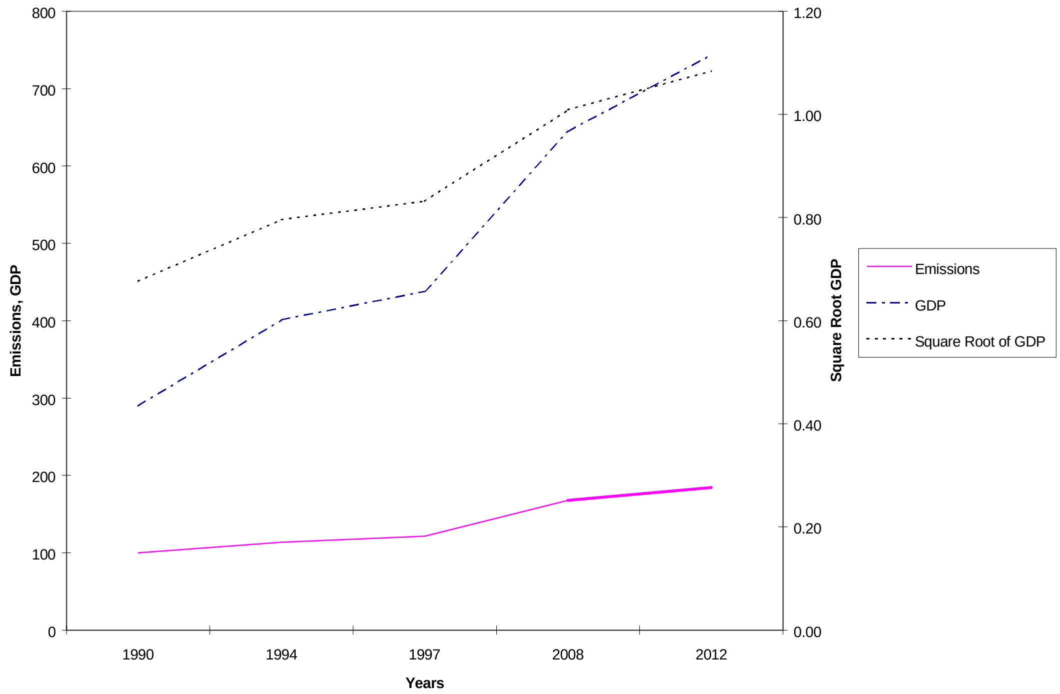
[16] Two additional options were studied and also discarded. On one side, the definition of a dynamic target based on the index of emissions intensity, without including some part or the whole Farming Sector. The advantages would be the reduction of dispersion in emissions between extreme scenarios, but the disadvantages would be that it would be politically unsustainable at an international level because a great percentage of GDP's emissions would be excluded. A second option that was considered was the definition of a combined index of GDP. This is, consumed electricity and production of meat with weights according to the contributions of each sector to total emissions. The advantages would be that the index could not be considered so "made-to-measure" for Argentina as the exclusion of the Farming Sector – the adaptability to different countries was thought of, by means of different values of those weights- but fundamentally because this index obtained a better adjustment with the evolution of the emissions. But, its main disadvantage would be that it did not create good incentives, because for example, improvements in the rational use of energy would simply derive in less emissions permitted, and therefore completely discouraging their adoption.

Figure 8. Comparison between Emissions, GDP and Square Root of GDP (base Emissions 1990=100)



Formally, in terms of our equations, the allowed emissions are set as:

$$E_P(t) = K \cdot \sqrt{GDP(t)} \tag{11}$$

where K is a parameter. In turn, for the target to be comparable to sections a) and b), K is defined from equalling (5) and (11):

$$K = (1-\rho) \cdot \frac{E^R_{BAU}(t)}{\sqrt{GDP^R(t)}} \tag{12}$$

And, once more, combining (2), (3) and (11) it is possible to obtain the commitment assumed for each one of the nine scenarios of:

$$RE(t) = \alpha \cdot PBI(t) + c - K \cdot \sqrt{GDP(t)} \tag{13}$$

From (11), it results that it is still valid that to a greater GDP, greater will be the allowed emissions since: $\frac{\partial E_P(t)}{\partial GDP(t)} = \frac{K}{2 \cdot \sqrt{GDP(t)}}$ > 0, with K and GDP > 0. But, as may be deduced from (13), the sign of the relation between RE(t) and GDP(t) will depend on circumstances. More concretely, of the relation between α, K, and the root of GDP(t), because: $\frac{\partial RE(t)}{\partial GDP(t)} = \alpha - \frac{K}{2 \cdot \sqrt{GDP(t)}}$.

As to the specific case of Argentina, to assume a ρ=0, implies that the commitments effectively assumed involve effective reductions of approximately 2% or 2 MTCE in the scenarios of Low GDP (Low or Middle Agriculture Sector) or of 9.4% or 11.5 MTCE in the High GDP-High Agriculture Sector scenario. There would not be generation of “hot air” in any case for the level of the proposed target (see table 4 and figure 9). This type of target would imply increasing the emissions of GDP in the average 2008-2012 between 22 and 44% with respect to 1997. The corresponding emissions intensity index would decrease between 12 and 25% with respect to 1997.

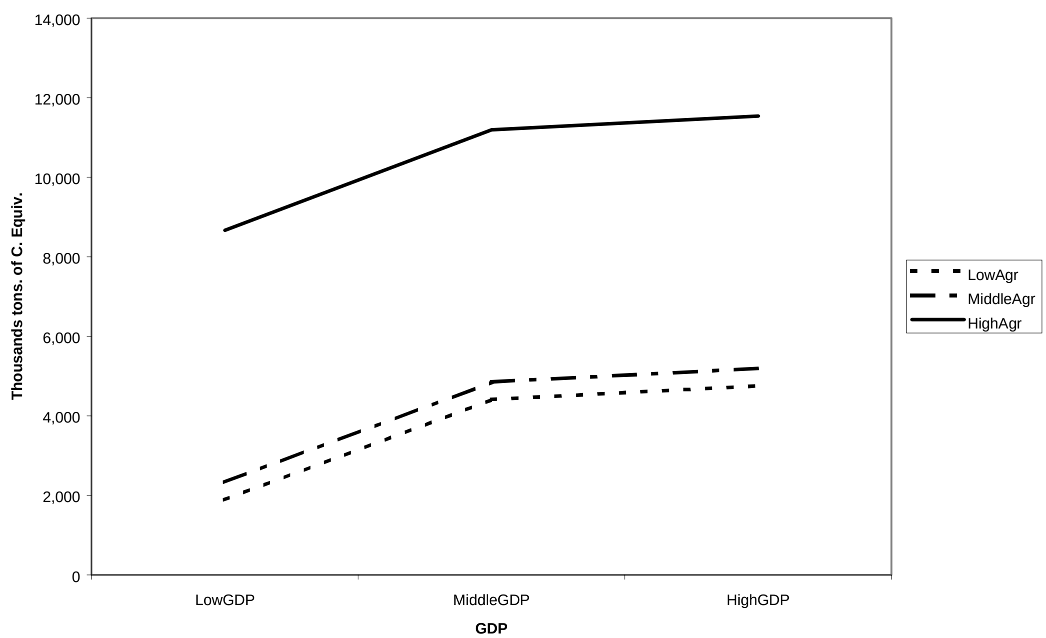
The main advantages of this option, adopted by Argentina´s authorities for their commitment are that: it incorporates the Agriculture Sector’s particular situation, it results in greater reductions of the required emissions when there is greater growth of GDP and in lower reductions when the rhythm of development decreases, and it does not generate “hot air” for the proposed level of target in any of the nine possible scenarios. The disadvantages are that it seams a “made-to-measure” option of Argentina and in that sense would not permit an easy generalisation to other developing countries, as is the idea of the emissions intensity index (on this matter see Center for Clean Air Policy, 1998). That this type of target should have been adopted by Argentina, does not imply that there could not be another (with respect to this, see Conte Grand and Gaioli, 1999).

Table 4. Commitment in each one of the projected scenarios under the Emissions/Square Root of GDP target

Scenarios	*EBAU(t)*	*EP(t) -ec.(11)-*	*RE(t)-ec.(13)-*	*Effort**
(average 2008-2012)	(miles de ton. de C. equiv.)			
LowGDP-LowAgr	95,582	93,694	1,888	2%
MiddleGDP-MiddleAgr	105,219	100,365	4,854	5%
HighGDP-HighAgr	122,272	110,730	11,542	9%
LowGDP-MiddleAgr	96,023	93,694	2,329	2%
LowGDP-HighAgr	102,365	93,694	8,671	8%
MiddleGDP-LowAgr	104,778	100,365	4,413	4%
MiddleGDP-HighAgr	111,561	100,365	11,196	10%
HighGDP-LowAgr	115,490	110,730	4,759	4%
HighGDP-MiddleAgr	115,931	110,730	5,200	4%

Note: * Effort is calculated as RE(t)*100/EBAU(t).

Figure 9. Emissions Reductions (RE) for the target set by the Emissions/Square Root of GDP Index (-10% of MiddleGDP-HighAgr)

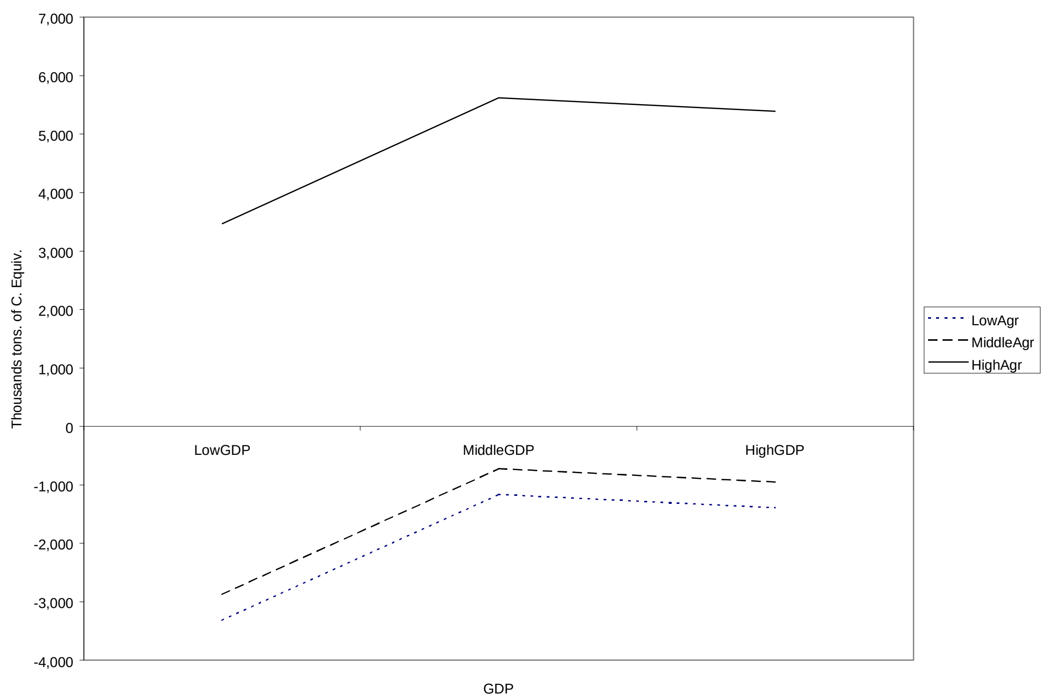


ii. Level of the Target

With respect to the level of the target, as has been mentioned above, the decision of the Argentine government has been to adopt a reduction of 10% of the emissions with respect to the BAU of the scenario Middle GDP- High Agriculture sector for various motives. The first of them has to do with the fact that in all cases the options for mitigation that were studied would permit the fulfilment of the target, leaving a margin for commercialising the reductions of additional emissions that may be obtained.

The second motive is that for index K to result in a positive relationship between RE(t) and GDP(t) without the generation of hot air, the target to be adopted should generate a reduction slightly superior to the 8% of GHG emissions with respect to the scenario of the reference (Middle GDP-High Agriculture Sector). Figures 10 shows that if, for example, a mitigation of only 5% were made with respect to the scenario of reference, the target would not be valid since there would not be real commitment except in the HighAgr scenario.

Figure 10. Emissions Reductions (RE) set by Emissions/Square Root of GDP Index (-5% ref. MiddleGDP-HighAgr)



III. Conclusions

The target that has been designed has the characteristic of not to become a limitation to development and at the same time eliminates the risks of generating "hot air". This is so because of its dynamics. The greater the growth of the country, the greater would be the allowed emissions (not to stop growth), but at the same time, the greater would be the commitment (in terms of emissions reductions with respect to BAU emissions). If the country goes through a period of recession, allowed emissions would be lower (not to generate "hot air"), but the commitment would also be lower (in terms of emissions reductions with respect to BAU emissions). In addition, this dynamic target takes into account the different behaviour of the Agriculture Sector, since the more it expands, the higher are the allowed emissions (and viceversa).

It has to be seen if the subsidiary bodies of the UNFCCC to study the target and advise the COP with respect to its content, and the consequence that accepting this target (whose adoption is conditioned to participation within the JI and the ET mechanisms without becoming an Annex B country) would have for the KP. In the meantime, Argentina could think of domestic policies for implementing it in the most flexible manner within the country if the new authorities decide to continue with this commitment. What is most certain that this target could bring benefits for the country, expressed by climate improvement and indirectly (through the adopted measures of mitigation) in the decontamination of local air, besides economic benefits by the reception of new investments, access to technology and new possibilities of participation in international markets. On the other side, the “early adoption” of the target could permit the country to take advantage of the less costly options of mitigation, besides giving it freedom of action for determining a target adequate to its growth needs. Lastly, this initiative would put Argentina in a really pro-active position in the world and would surely contribute to facilitate negotiations for the entry into force of the Kyoto Protocol.

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