An assessment of strategies for the control of both climate change and air pollution emissions in Spain. Results from the power, transport and waste management sectors.

J.Lumbreras*, A. Guijarro, R. Borge & E. Rodriguez.
Department of chemical and environmental engineering. Technical University of Madrid (UPM).
José Gutierrez Abascal 2. 28006. MADRID (SPAIN)
*Corresponding author. E-mail: jlumbreras@etsii.upm.es

Introduction

Currently, it is becoming more relevant to take into account holistic strategies to face up to any environmental challenges, considering social and economical implications in order to assure the sustainability of the measures to adopt. Among them, climate change and air pollution are two of the main scopes that affects people's quality of life.

The goal of any public administration with competence in these issues is to performance the appropriate measures to achieve the environmental objectives in an optimal cost-efficient way.

Policies and measures aimed at control climate change can have important effects on air pollution emissions, and *vice versa*, quite often in a positive way but not always. In both situations, to develop a strategy to solve any of these two problems is necessary to assess the synergies and limitations of combined measures that can multiply the emission reductions leading to optimal cost-efficient scenarios.

However, there are several aspects that complicate the achievement of the pursued goals. This paper study, with accuracy, the effects of national/regional strategies that combine preventive, process and end of pipe actions over the climate change and air pollutions emissions reductions, or that takes into account both technological and people change-behavioural measures. One of the objectives is to support authorities to justify and put into practice that combined policies. It also provides technical arguments to base policies processes and to adopt the optimal measures.

Consequently, there are great opportunities for combined climate change and air pollution measures, but is necessary to analyze and quantify the effects of them to define the best social-economical-environmental strategy.

Methodology

In order to assess the potential impacts of policies and measures in both climate change and air pollution emissions a three-step approach has been developed. The steps are as follows: i) identification of activities with higher emissions, ii) in-depth examination of critical parameters for each such activity, and iii) evaluation of the influence in GHG and air pollution emissions of changes in the parameters.

These steps have been applied to Spanish emissions. In the first step the 20 most important activities, which are those with a contribution greater than 5% of the total national emissions of any pollutant included in Spanish National Atmospheric Emission Inventory (SNAEI), are identified. Following this approach, at least 70% of the total emissions for each pollutant are covered except for NMVOC and N_2O (Table 1). Secondly, 41 parameters came out leading the critical policies and measures to reduce emissions. Finally, resulting emissions from changing any parameter or applying policies and measures are evaluated.

Table 1. Most emitter activities in Spain including their percentage of total 2000 emissions (SNAEI).

#	SNAP code	SOx	NOx	VOC	CH_4	CO_2	N_2O	NH_3	SF_6	HFC	PFC
1	01.01.01	63,6	17,9	0,2	-	27,7	0,9	-	-	-	-
2	02.02.02	1,1	1,2	1,5	1,6	5,4	0,7	-	-	-	-
3	03.01.03	4,9	1,8	0,1	0,1	5,8	0,5	-	-	-	-
4	03.03.11	3,5	3,7	-	-	3,2	0,3	-	-	-	-
5	04.03.01	0,3	0,1	-	-	0,2	-	-	-	-	90,3
6	04.06.11	-	-	4,5	-	-	-	-	-	-	-
7	04.06.12	-	-	-	-	4,9	-	-	-	-	-
8	04.08.01	-	-	-	-	-	-	-	-	36,0	-
9	06.05.02	-	-	-	-	-	-	-	-	44,3	9,1
10	06.05.06	-	-	-	-	-	-	-	-	15,3	-
11	06.05.07	-	-	-	-	-	-	-	10-	-	-
12	07*	1,1	37,3	7,4	0,5	25,0	6,5	1,4	-	-	-
13	07.06.00	-	-	3,4	-	-	-	-	-	-	-
14	08.06.00	0,1	7,2	0,6	-	2,2	0,2	-	-	-	-
15	09.04.01	-	-	-	15,4	-	-	-	-	-	-
16	10.01.02	-	0,6	6,1	-	-	23,5	38,1	-	-	-
17	10.01.05	-	0,1	-	-	-	16,8	12,1	-	-	-
18	10.0X	-	-	-	25,3	-	-	5,6	-	-	-
19	10.0X	-	-	-	21,2	-	-	14,9	-	-	-
20	10.0X	-	-	-	12,3	-	-	0,7	-	-	-
TOTAL		**74,5%**	**69,9**	**23,8**	**76,4**	**74,5**	**49,3**	**72,9**	**100,0**	**95,6**	**99,5**

* Except 07.06 (Gasoline evaporation) and 07.07 (tyre and brake wear)

Results

In this paper, three of the most important sectors have been selected. They are road transport, waste management and electricity generation from large power plants. Three different approaches are applied to analyse the effects of different measures and to evaluate if they have ancillary benefits or, otherwise, the have opposite impacts in terms of atmospheric emissions.

In road transport sector, technological measures applied to gasoline cars are evaluated. Figure 1 shows the influence of using Euro engines instead of those with engines produced before 1993. Great NOx, VOC and NH_3 emission improvements are achieved (71%-97% for VOC and NOx and 59%-71% for NH_3). Regarding Total Solid Particulate (TSP), euro technologies could achieve lower but significant reductions (45%-83%). Nevertheless, new technologies are not able to reduce neither SO_2 nor CO_2 emissions. Their implementation in the Spanish baseline scenario for 2010 gives a reduction between Euro II and Euro III (86% for NH_3, 84% for NOx and VOC, and 67% for TSP).

With regard to urban waste management, figure 2 shows different possible P&M useful to reduce emissions. Some of them are prior to waste management, such as waste prevention, reusing policies, technologies for reducing wastes, treatment-recycling distribution and public awareness. In this paper we focus the attention on waste management technologies when residues are generated and should be treated. The alternatives considered are: uncontrolled landfill, controlled landfill (including biogas collection with energy generation) and waste incineration. Figure 3 presents the Spanish results for 2010 compared to 2001 within two scenarios: without measures and with measures (baseline). Waste distribution hypothesis for each scenario are shown in table 3. Emissions under the without measures scenario increase for every pollutant. On the other hand, the implementation of controlled landfilling and waste incineration lead to a 73% decrease in methane emission. However, the change in waste management produces an increase of other emissions: SO_2, NOx, VOC, CH_4, CO and CO_2 emissions from incineration increase from 141% to 150%, and CO_2 emissions from biogas combustion to produce electricity grow even more steeply (356%).

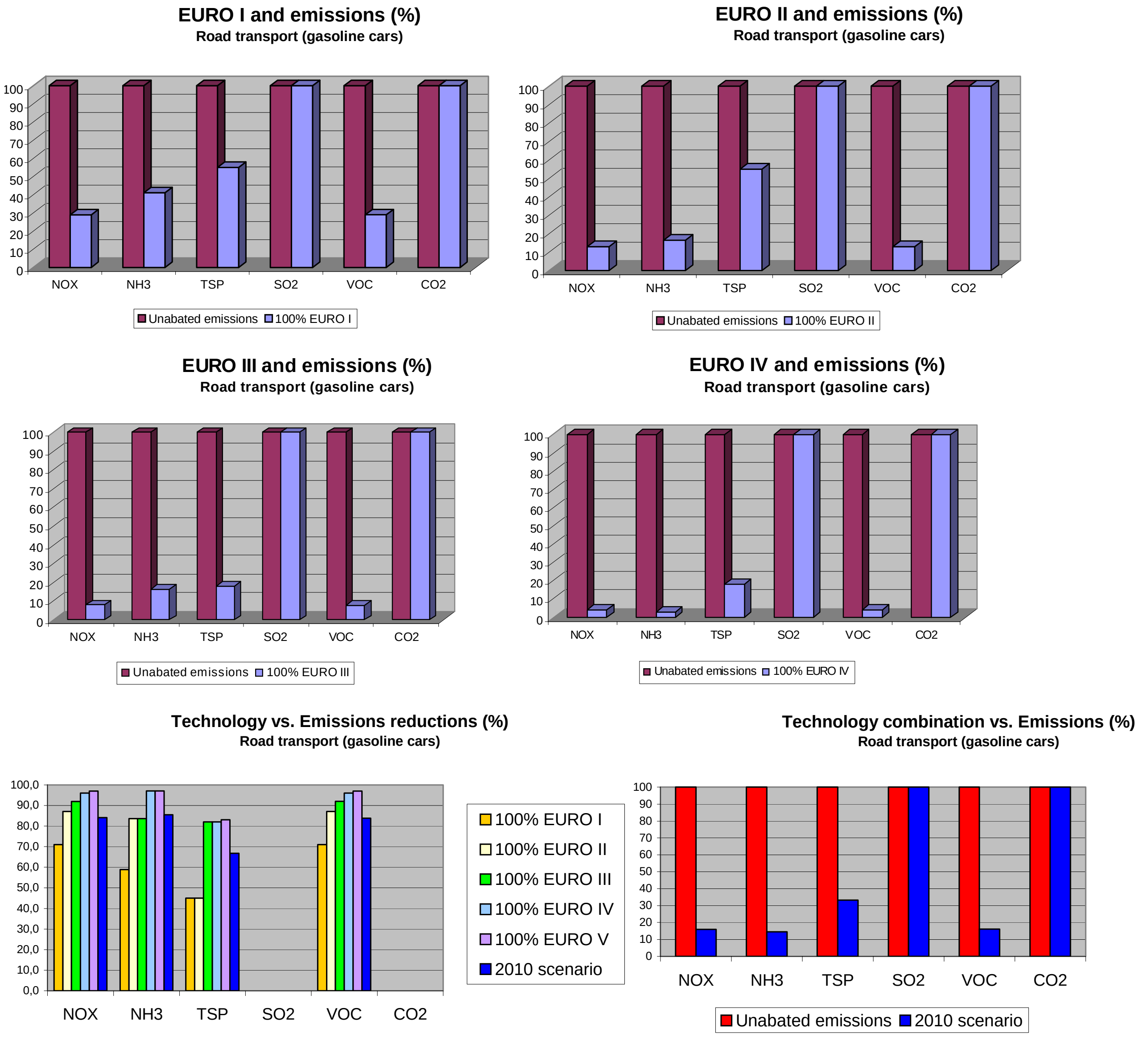

Figure 1. Combined effect of Euro Technologies in gasoline vehicles from road transport using CEP methodology. Results for Spain.

In spite of the fact that some emissions increase while CH_4 are reduced, the critical aspect is to compare the changes in terms of the effects. The last illustration of figure 3 shows that, in terms of equivalent CO_2 emissions, the measures included in the scenario cut down them in 5892 kt due to landfill application with biogas collection whereas biogas production and incineration raise GHG emissions in 64 kt and 840 kt respectively. As a consequence, total equivalent CO_2 decline 4988 kt.

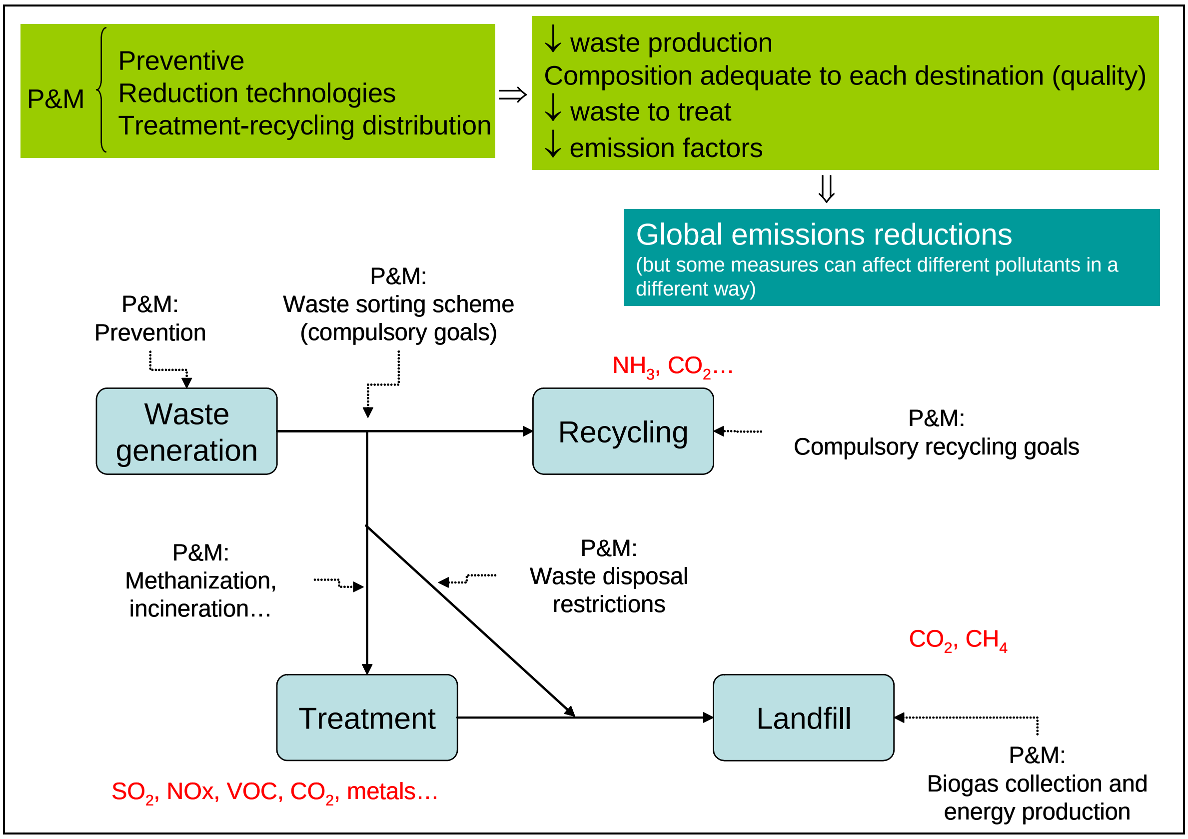

Figure 2. Emissions of alternative P&M in waste management sector.

Table 2. Waste treatment distribution hypothesis under considered scenarios

Activity	**Without measures**		**With measures**	
	2001	**2010**	**2001**	**2010**
Sorting scheme	7,0%	10,6%	19,3%	26,4%
Uncontrolled	7,5%	2,5%	5,0%	0,0%
Composting	21,0%	23,4%	22,2%	26,2%
Incineration	7,0%	9,2%	9,0%	17,7%
Landfill disposal	57,5%	54,3%	44,5%	29,7%
CH4 recovery (landfills)	12,28%	23,09%	17,60%	75%

Finally, the effect of changing energy demand and substituting fuel consumption in electricity sector is studied. Figure 4 shows 2010 emissions for Spanish large combustion plants under 5 scenarios: baseline, a change of ±10% in 2010 primary energy consumption for electricity generation, a 10% substitution of 2010 coal consumption into Natural Gas and a 10% switch of 2010 coal consumption to Natural Gas.

Changes in primary energy consumption modify NOx and CO_2 emissions in around 5 and 10% respectively. However, it does not influence SO_2 emissions due to the great expected penetration of desulphurization technologies in 2010 power plants in Spain. Nonetheless, fuel substitution has a greater effect in emission reductions. If 10% of 2010 coal consumption is substituted by gas, SO_2, NOx and CO_2 emissions will be cut in 2%, 16% and 20% respectively. In case of switching from gas to coal, emissions will increase but they will not have such a big change because the projected coal consumption for 2010 is lower than for gas.

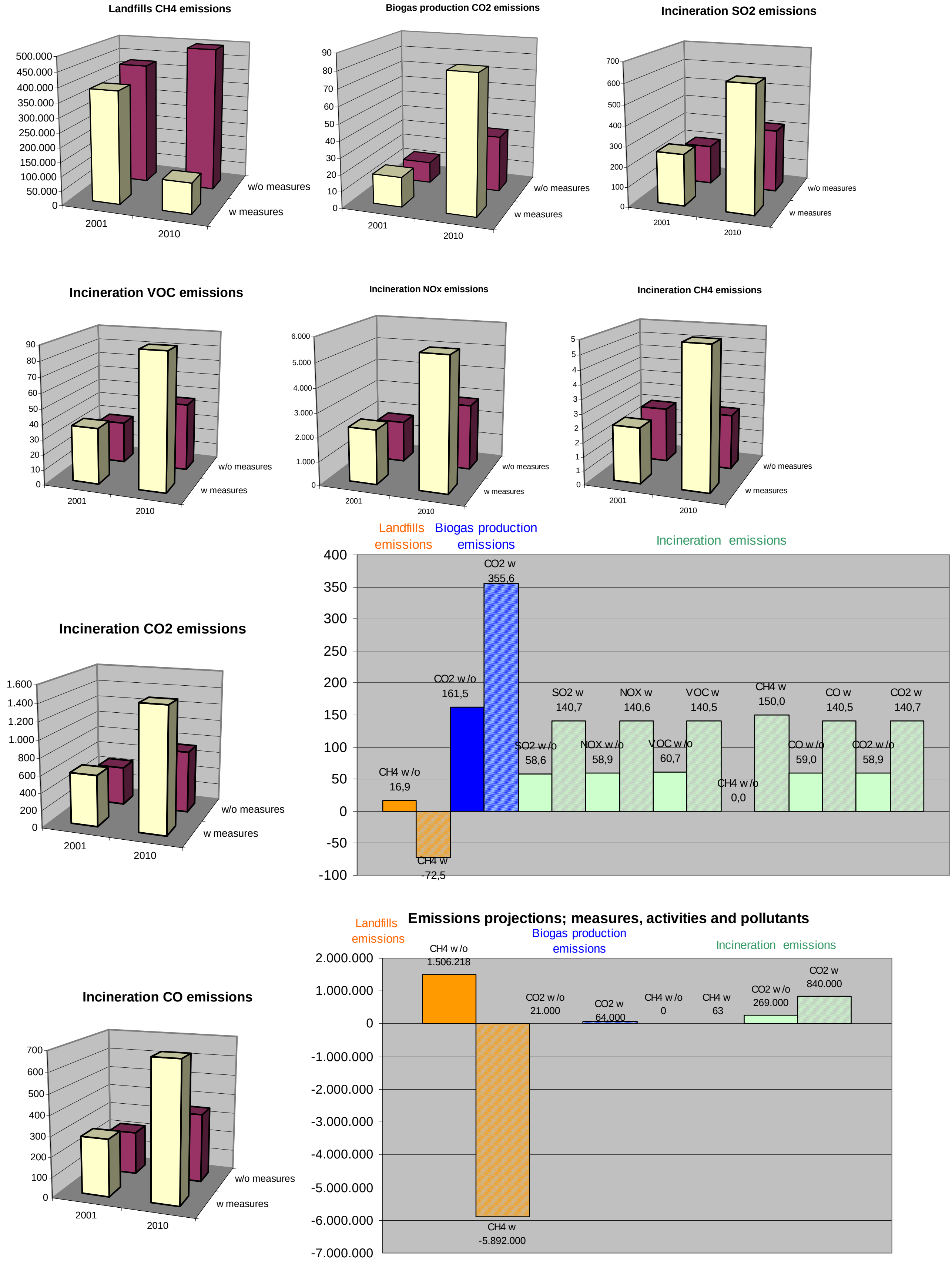

Figure 3. Combined effect of urban waste management alternatives using CEP methodology. Results for Spain.

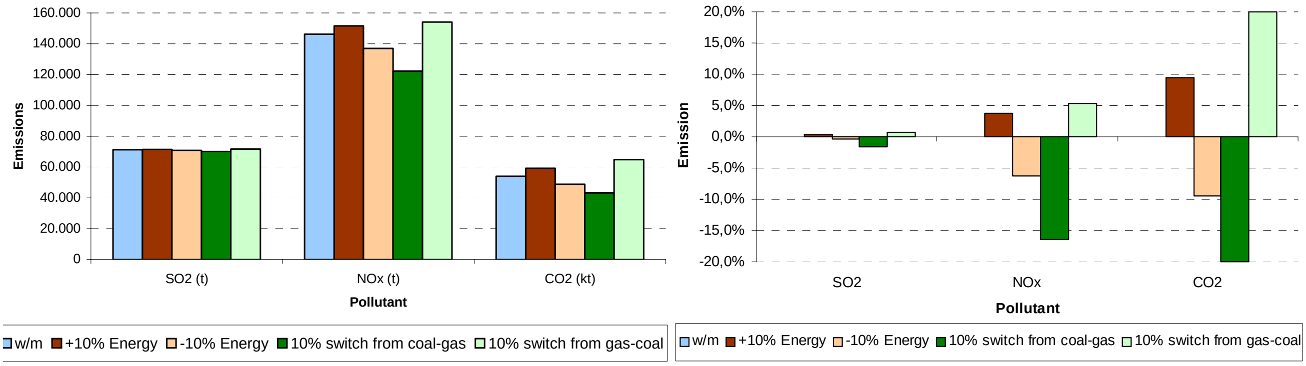

Figure 4. Effect of changes in energy demand and fuel substitution for large combustion plants using CEP methodology. Results for Spain.

Conclusions

The combined effects of policies and measures are analyzed for three of the most important Spanish sectors from the atmospheric emissions point of view. The assessment allows a quantification of the consequences of different strategies for the control of both climate change and air pollution emissions. Power, transport and waste management sectors have been selected from the 20th most emitter activities.

For transport sector, implementation of technologies has considerable ancillary benefits in terms of emissions. Penetration of gasoline Euro engines could reduce up to 97% of NOx, NH_3 and VOC simultaneously. They could also decrease PM emissions in 83%. However, the effect in SO_2 and CO_2 emissions is insignificant.

For the power sector, fuel substitution has a co-benefit in air quality and GHG emission reduction. Moreover, in terms of emissions, the effect is higher than energy saving. Compared to a 10% primary energy saving, a 10% switch from coal to gas with the expected fuel mix for Spain in 2010 contributes to increase SO_2, NOx and CO_2 reductions in a 1.1%, 10.1% and 10.5%.

Finally, in the waste management sector, policies and measures have effects in different ways. A combined strategy for 2010 waste management in Spain that consists of avoider uncontrolled landfill, energy use of biogas collected from controlled landfills and waste incineration reduces GHG emissions in 66% but increases NOx, SO_2, VOC and CO emissions between 141% to 150%.

Further work should focus the attention on a cost/benefit assessment in order to obtain the cost per unit of emission reduction for each measure.