Regional and Sectoral Effects of Environmental Voluntary Agreements

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Abstract

GreenMod is a modelling platform for regional, sectoral, international, and intergenerational analysis for energy and environmental issues. The current version is a recursively dynamic CGE model with imperfect competition, increasing returns to scale, and a detailed disaggregation level of the households, the firms, and the government.

This paper presents the model GreenMod and an application regarding the impacts of the environmental agreements (EA) on the three Belgian regions (Brussels, Flanders and Wallonia).

Keywords: general equilibrium models, environmental agreements, climate change, Belgium.
JEL Classification: C68, R13, Q58.

1. Introduction

On 25 April 2002, the Kyoto Protocol has been approved on behalf of the European Community by Council Directive 2002/358/EC[1]. The Protocol entered into force on 16 February 2005, after its ratification by Russia on 18 November 2004, and it became legally binding on its 128 parties. The enforcement of the Protocol commits the Member States to

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[1] Official Journal of the European Union, L 130, 15.05.2002, p.1-20.

reduce the emissions of greenhouse gasses in Annex A (CO_2, CH_4, N_2O, HFCs, PFCs, SF_6)[2] by 8 per cent during the period 2008-2012, compared to their 1990 levels. The target will be shared between the Member States. The burden-sharing agreement is set in Annex II of the Council Directive 2002/358/EC, and assigns emission cuts to each member state ranging from 4 to 28 per cent. In this context, Belgium has agreed to reduce its emissions of greenhouse gases for the period 2008-2012 by 7.5 per cent compared to its level of 1990.

The increasing awareness of the need of an efficient environmental policy at the European Community level during the 1990s resulted in broadening the types of policy instruments and the integration of environmental policies in sectoral policies. Thus, the Fifth Environmental Action program 1993-2000[3], drew up by the European Commission, implied greater use of economic instruments, such as taxes and charges and, under certain conditions, voluntary approaches. Voluntary approaches represent commitments from polluting firms or sectors aiming at improving their environmental performance.

In the energy-intensive sectors, the fear of enforcing the CO_2 taxes at either national or EU level, which were perceived as affecting the international competitiveness, lead to the implementation of environmental agreements in several countries, including Belgium. The voluntary agreements are thought to be a cost-effective solution to CO_2 reduction (Krarup and Ramesohl, 2002). They also aim at strengthening the dialogue between the government and the business community. The Sixth Environmental Action program[4] further encourages voluntary agreements to achieve the stated environmental targets, which are thought to improve the partnership with enterprises, leading to gains in environmental performance of enterprises and to sustainable production patterns.

To study different aspects of voluntary measures designed to improve environmental quality, a network consisting of European government agencies and universities has been created, with the financial support from the European Commission. Its main workgroups: CAVA (Concerted Action on Voluntary Approaches); NEAPOL (Voluntary Agreements Policy Lessons to be Learned) and VAIE (Voluntary Agreement Implementation and Efficiency) evaluated voluntary systems in many countries. However, neither of these studies assesses the general equilibrium effects of implementing such type of environmental measures on different economic actors.

In this paper, we use the GreenMod model to assess the economic impacts at the sectoral and regional level of the implementation of environmental agreements (EA) in Wallonia and Flanders.

[2] Annex A of Kyoto Protocol available at: http://unfccc.int/resource/docs/convkp/kpeng.pdf.
[3] Official Journal of the European Union L 138, 17.05.1993, p.5-98.
[4] Official Journal of the European Union L 242, 10.09.2002, p. 1-15.

Next section provides the main issues regarding the Belgian National Allocation Plan and the pre-Kyoto measures undertaken by the regions. Section 3 provides an overview of the model. We present and discuss the simulation results in section 4 and conclude in section 5.

2. Some basic facts

Given the federal structure of the Belgian State, the emission reduction will be shared between the federal government and the three regions (Flanders, Wallonia and Brussels).

There are big differences in the economic structure of the three Belgian regions. The Brussels region, due to its limited size, is characterized by a high population density and very few industries. Most of its emissions stem from heating by the households and services sectors, and from transport activities. The total emissions in the Brussels region represent only about 3 per cent of the total emissions of Belgium. Flanders and Wallonia have a much more developed industrial structure. Currently, Flanders is responsible for about 60 per cents of the total emissions of Belgium and Wallonia for the remaining 37 per cent.

On 8 March 2004, after more than 5 years of long and complex negotiations, the federal and the regional governments came to an agreement to share the burden of the reduction in the emissions in the following way: the Walloon region will reduce its emissions by 7.5 per cent compared with the 1990 levels, the Flemish region by 5.2 per cent, and Brussels is allowed to increase its emissions by nearly 3.5 per cent (see table 1). Due to the fact that the total reduction would not meet the assigned amount given to Belgium, the rest of the reduction will be achieved by the federal government through the flexible mechanisms anticipated by the Kyoto Protocol.

Table 1: Burden sharing of the reduction in the GHG between the regions and the federal government

Regions	Emissions 1990	Emissions allowances allocated for the period 2008-2012
	Million of tons CO2 equivalent	
Flanders	87.95	416.86
Wallonia	54.30	251.14
Brussels	3.99	20.64
Total emissions allocated to the regions:		688.64
Assigned amounts to Belgium:		676.36
Amount of emissions to be acquired by the federal government through flexible mechanisms		12.28

Source: Belgian National Allocation Plan, June 2004.

The regions have the freedom to decide how to reach their respective targets. One of the pre-Kyoto tools used by the Walloon and Flemish regions is the adoption of environmental agreements. These agreements are negotiated at sectoral level or by companies directly and

imply a reduction of the greenhouse gases covered by the Kyoto Protocol or an increase in the energy efficiency by the companies.

In the Flemish region, the purpose of the sectoral agreements is first to reach a decrease of its emissions to the level of 1990, and then to further decrease them to reach the Kyoto target. Therefore, the Flemish region encourages the residential companies to reach the world best performance in the energy efficiency. Energy plans have been defined by sectors or firms in order to reach this efficiency. In exchange for the fulfillment of the energy plans, the regional Flemish government has agreed not to impose additional measures aiming at increasing the energy efficiency and reducing the GHG emissions, and has provided free emissions allowance equal to the target fixed in the energy plan.

On November 29, 2002, the Flemish Covenant Energy Benchmarking was approved by the Flemish Government. By January 11, 2006, 179 firms as well as 14 sectoral organizations have signed an agreement. The working period for the Covenant is up to 2012.

Based on the latest available evolution report, the following increase in the energy efficiency would be reached by 2012, taking 2003 as the base year (see table 2). These values have been used for setting up the policy scenario, evaluated using the GreenMod model.

Table 2: Increase in the energy efficiency to be achieved in Flanders by 2012, by industries undertaking environmental agreements (base year 2003)

Production sectors		IEE adjusted
Manufacture of food products and beverages	sec06	15.25%
Manufacture of pulp, paper and paper products	sec07	11.68%
Manufacture of coke, refined petroleum products and nuclear fuel	sec08	4.92%
Manufacture of chemicals and chemical products	sec09	9.48%
Manufacture of other non-metallic mineral products	sec10	
Ceramic		2.83%
Glass		8.65%
Manufacture of basic metals	sec11	
Steel		4.92%
Metallic		7.35%
Manufacture of motor vehicles, trailers and semi-trailers	sec18	7.35%
Other manufacturing	sec20	
Textile		10.10%
Wood		0.28%

Source: Commissie Benchmarking Vlaanderen, (2004), Evaluatieverslag 2002-2004 and own calculation.

Note: IEE represents the energy efficiency index.

Regarding Wallonia, various environmental agreements have also been signed with the local industries to reduce their CO_2 emissions and to increase their energy efficiency.

The Walloon government has agreed, in exchange for the implementation of the environmental agreements, not to impose any other additional measure leading to gains in energy efficiency or the reduction in the greenhouse gasses emissions, on the concerned

companies. Furthermore, for the first emission trading period (2005-2007) the government has granted the free allocation of emissions allowances for the sectors undertaking sectoral agreements, while preferential treatment is envisaged for the second trading period (2008-2012). In case of new entrants during the period 2005-2007, they will be granted free emission allowances using the allowances reserve.

By June 2004, a number of environmental agreements were concluded with the Walloon Region. The agreements signed with the Multisector federation for the technology industry (AGORIA), Federation of Belgian dairy industry (CBL), Federation of Belgian cement industry (FEBELCEM), Federation of food industry (FEVIA), Federation of glass industry (FIV), Association of the Belgian pulp, Paper and Board Producers Association of the Belgian (COBELPA), Federation of chemical industries (FEDICHEM), CARMEUSE group and LHOIST group have already been published in the Belgian Official Monitor[5], together with their estimated increase in the energy efficiency. The sectoral agreement with the Belgian federation of bricks (FBB) and Federation of ceramic industry (FEDICER) is currently in the public consultation stage.

Based on these agreements, the increase in the energy efficiency by 2012, taking 2003 as the base year, has been used to set up the policy scenario (see table 3). The estimated increase in the energy efficiency is based on a potential reduction of the measure which corresponds to a pay-back period of less than 4 years.

The energy efficiency index is derived as:

$$IEE(t) = \frac{Total\ energy\ consumption\ (t)}{Energy\ consumption\ per\ unit\ of\ production\ (0)\ \cdot Production\ level\ (t)} \cdot 100$$

where *t* stands for the current year and *0* stands for the base year. Energy consumption refers to the primary energy consumption in this case. The increase in the energy efficiency is given by the difference between 100 and the value of IEE derived in this fashion.

In the Brussels region, no environmental agreements have been signed given that the vast majority of emissions come from the residential sector, the services sector and the transportation sector.

[5] Moniteur Belge No. 109, 30.03.2004, p. 17936-17937.

Table 3: Increase in the energy efficiency to be achieved in Wallonia by 2012, by industries undertaking environmental agreements (base year 2003)

Production sectors		IEE adjusted
Manufacture of food products and beverages	sec06	
Agricultural products processing		6.03%
Dairy products		6.02%
Manufacture of pulp, paper and paper products	sec07	14.08%
Manufacture of coke, refined petroleum products and nuclear fuel	sec08	5.56%
Manufacture of chemicals and chemical products	sec09	6.67%
Manufacture of other non-metallic mineral products	sec10	
Ceramic and bricks		3.04%
Glass		6.38%
Cement		5.70%
Lime (Carmeuse)		1.05%
Lime (Lhoist)		2.07%
Manufacture of basic metals	sec11	
Basic iron and steel		5.56%
Casting of metals		7.21%
Non-ferrous metals		12.67%
Manufacture of fabricated metal products	sec12	10.80%
Manufacture of machinery and equipment n.e.c.	sec13	10.80%
Manufacture of other transport equipment	sec19	10.80%

Source: Plan sectoriel d'accord de branche and own calculations.

Note: IEE represents the energy efficiency index.

3. Overview of GreenMod model

GreenMod is a dynamic multi-sector inter-regional computable general equilibrium (CGE) model for the Belgian economy, used to analyze problems related to environment and energy at the federal and regional levels (Bayar *et al.*, 2006). The three regions of Belgium (Wallonia, Flanders and Brussels) are explicitly modelled in GreenMod, taking into account both the interdependences between each other and the links between each region and the rest of the world. The model incorporates the economic behaviour of four economic agents in each region: firms, households, government and the rest of the world. In addition to the agents described at the regional level, the federal government and the French Community are explicitly modelled.

All economic agents are assumed to adopt an optimizing behaviour under relevant budget constraints. The goods-producing sectors, consisting of both public and private enterprises, are disaggregated into 30 sectors. The model distinguishes 37 types of commodities, allowing for one production sector to produce more than one type of commodity and also for different production sectors to produce the same type of commodity[6].

GreenMod explains the differences in the industry structure between the regions by variation in the economies of scale. This is a usual simplifying assumption made in general equilibrium models (Harris, 1984, Willenbockel, 1994). Strategic interactions between firms in an imperfectly

[6] A presentation of the production sectors and commodities considered in the model is given in Appendix A.

competitive industry are represented using spatial Cournot oligopoly framework with free entry and exit. This framework has recently been used in general equilibrium literature to model firms' location and different industry structures for studying energy related issues (Babiker, 2005).

GreenMod incorporates the representation of a range of oligopolistic sectors. These sectors differ in their regional location, the number of operating firms and the degree of the economies of scale, which they enjoy. Each individual firm is a profit-maximiser. It chooses its output level based upon its marginal costs and the price elasticities of demand that it faces. The behaviour of individual firms defines the overall performance of the oligopolistic industry in terms of number of operating firms, output and price levels. Performance of an oligopolistic industry is represented using Cournot-Nash equilibrium.

All oligopolistic firms in GreenMod are country level oligopolists. They exercise their market power over all Belgian regions and cannot price differentiate between them. They take into account the weighted perceived elasticities of demands of all Belgian regional markets while choosing their outputs and prices.

Households are split into two income groups, allowing analyzing the income distribution effects of the policy measures. Government behaviour is modelled at three different levels: federal, regional, and community (French community). Both federal and regional tax systems are modelled in a detailed way. With regard to the rest of the world the economy is treated as a small open economy with no influence on world market prices.

The model has a recursive dynamic structure composed of a sequence of several temporary equilibria, in which current savings determine future capital accumulation and the growth rate of the economy. The endogenous determination of investment behaviour is essential for the dynamic part of the model. Investment and capital accumulation in year *t* depend on expected rates of return for year *t+1*, which are determined by actual returns on capital in year *t.* The simulation horizon of the model is set at 25 years but can be extended in a flexible way. The model is solved dynamically with annual steps.

The targets established by the Kyoto Protocol for the emissions reduction require an important change in the structure of consumption and production in the short-run. However, the use of a less carbon-intensive input mix in the production process requires large replacement or retrofit rates for the capital stock. Therefore, special attention has been paid to modelling of capital structure and its evolution over time in GreenMod. Two types of capital are distinguished in each period: a "malleable" part and a "rigid" part (Jacoby *et al.*, 2004), whereas the possibilities of substitution among factors of production are assumed to be higher for the malleable than for the rigid capital (vintage capital). Thus, the technology is assumed to have a putty/semi-putty specification (Van der Mensbrugghe, 1994).

Technical change is represented in the model by three types of backstop technologies: a carbon-free electric power generation based on biomass, a carbon-free electric power generation based on wind power and a hydrocarbon-intensive technology for natural gas (coal gasification).

GreenMod is calibrated on a highly disaggregated inter-regional Social Accounting Matrix for Belgium for the year 2003.

4. The implementation of environmental agreements in Wallonia and Flanders

In this section, we evaluate the sectoral and regional effects of implementing the environmental agreements in Wallonia and Flanders. The sectors which signed environmental agreements in the two Belgian regions and their corresponding targets in energy efficiency to be achieved by 2012 have been summarized in section 2, tables 2 and 3. In GreenMod, the targets are increased gradually during 2003-2012. The effects of cogeneration have not been taken into account in this scenario.

From the theoretical point of view, voluntary agreements imply multiple effects, some of which can go in opposite directions. In the short-run, the agreements could increase the unit production costs due to the adjustment costs (external or internal). However, the literature shows that the increase is not always significant, and depends on a number of factors such as the legislation, the economic, technological, and institutional context in which the firm (or the sector) is operating (Krarup and Ramesohl, 2002, Linden and Carlsson-Kanyama, 2002, Chidiak, 2002, Grepperud, 2002). Furthermore, these costs are not always linked to the investments induced by the agreement. Krarup and Ramesohl (2002) further suggest that they could have a limited impact on investment criteria and planning related to the investment in energy efficiency technologies unless it is explicitly required, by relaxing the pay-back requirements (e.g. the Danish case).

On the medium and long term, the voluntary agreements could also have ambiguous effects due to two opposite mechanisms. On one hand, the firms should increase their energy efficiency to reach the target set by the agreements, and therefore lower their energy consumption per unit of output. On the other hand, as the energy efficiency increases, the unit production cost declines, which leads to firms increasing its total production and therefore its total energy consumption. This is furthermore true, when the energy efficiency is a prerequisite in decreasing the fiscal expenditures on the energy per unit of output, like in the Danish scheme[7] (Johansen, 2002). As a result, no certain conclusions can be drawn on the effects of the voluntary agreements on production or employment. The studies on the

[7] The Danish scheme gives access to lower tax rates on CO_2 emissions for the energy-intensive plans joining the agreements.

effects of such arrangements are still sparse. However, Bjorner and Jensen (2002) and Khanna and Damon (1999) suggest that the voluntary agreements tend to have a significant impact in reducing energy consumption. The reduction might be achieved through the increase of the energy efficiency, even when the firm increases its production.

Finally, the effect of the voluntary agreements on the firms' external competitiveness is not always negative. This depends on the efficiency gains that the company can achieve compared to its adjustment costs, and to the changes in the relative prices in the economy. The competitiveness could therefore either improve or worsen. The only way to answer to these questions by taking into account the multiple effects is through quantitative analysis.

Simulation results with GreenMod show that the macroeconomic effects of implementing the voluntary agreements schemes would be positive in the long run: at the national level the real GDP would increase by 0.29 per cent in 2012 compared to the baseline (see table 4), while at the regional level the real GDP would increase by 0.29 per cent in Wallonia, and by 0.34 per cent in Flanders.

Table 4: Macro and regional effects of the implementation of the environmental agreements

Macro and regional effects		2006	2007	2008	2009	2010	2011	2012
Macroeconomic effects								
GDP (% change)		0.13	0.17	0.21	0.23	0.27	0.28	0.29
National savings (% change)		0.14	0.19	0.23	0.27	0.31	0.32	0.34
Unemployment rate (%)		8.13	8.11	8.12	8.12	8.11	8.09	8.07
Regional effects								
Regional GDP (% change)	wal	0.10	0.14	0.18	0.22	0.25	0.27	0.29
Regional GDP (% change)	vla	0.16	0.21	0.27	0.28	0.33	0.34	0.34
Regional GDP (% change)	bru	0.05	0.07	0.08	0.09	0.09	0.10	0.10
Unemployment rate (%)	wal	10.73	10.70	10.71	10.69	10.68	10.68	10.67
Unemployment rate (%)	vla	5.44	5.44	5.46	5.48	5.48	5.45	5.43
Unemployment rate (%)	bru	15.63	15.51	15.42	15.33	15.25	15.22	15.18

Note: If not indicated otherwise, all the variable are reported as percentage change compared with the baseline. Wal stands for Wallonia, vla for Flanders and bru for Brussels region.

Unemployment rate drops by 0.16 percentage points at the national level in 2012 compared to the baseline, due to the increase in domestic production which leads to an increase employment demand by the sectors. At the regional level, Wallonia achieves a reduction of 0.17 percentage points and Flanders 0.16 percentage points in 2012.

The results are driven by the increase in the energy efficiency in the sectors which signed the environmental agreements. The growth in the energy efficiency leads to a decline in the production costs of the sectors combined with a fall in the consumption of energy inputs (see table 5). In Brussels, although no voluntary agreements have been implemented, the real GDP increases by 0.10 per cent in 2012 compared to the baseline, due to the positive effects induced by the other two regions through the changes in relative prices. The higher impact

on the real GDP in Flanders compared with Wallonia is attained due to the larger efficiency gains in the Flemish region.

The decline in the production costs achieved through the increase in the energy efficiency by the EA sectors leads to a decrease in the consumer prices, and therefore to a rise in the private consumption of these products by both households' income groups. Thus, gross output of most sectors that implemented environmental agreements in Wallonia and Flanders goes up (see table 5). Consequently, employment by the sectors rises.

Gross output of manufacture of coke and refined petroleum products, of production and distribution of natural gas sector and of production and distribution of nuclear and non-nuclear electricity sectors declines due to the reduction in consumption of energy inputs by the sectors that implemented environmental agreements, which overweight the rise in private consumption. Subsequently, employment by the sectors diminishes. Overall, the increase in employment demand by the EA sectors overweight the drop in employment by the energy producing sectors and thus unemployment rate at both national and regional levels goes down (see tables 4).

The measure seems to have positive effects in terms of external competitiveness (see table 5). In most of the environmental agreements sectors, the relative decline in the domestic prices compared to the world prices induces a rise in the competitiveness and thus exports increase.

The implementation of environmental agreements in Wallonia and Flanders leads to a reduction in the regional CO_2 emissions due to the drop in the energy consumption by the EA sectors (see table 5), even though production by the sectors goes up. This is in line with the finding of Bjorner and Jensen (2002) and Khanna and Damon (1999). At the national level, the measure results in a 1.55 per cent reduction of the CO_2 emissions in 2012 compared with the baseline (see table 6). The highest contribution to the CO_2 abatement is given by Flanders, with 2.11 per cent cut compared with the baseline.

Table 5: Sectoral and regional effects of the environmental agreements adoption in 2012

Production sectors		Energy efficiency gains		Percentage change in the energy used		Price of output		Production		Exports		CO2 emissions	
		wal	vla	wal	vla	wal	vla	wal	vla	wal	vla	wal	vla
Manufacture of food products and beverages	sec06	6.03	15.25	-5.59	-15.34	-0.28	-0.35	0.24	0.55	0.31	0.71	-5.65	-15.39
Manufacture of pulp, paper and paper products	sec07	14.08	11.68	-12.68	-10.99	-0.74	-0.36	1.49	1.44	1.90	1.54	-12.78	-10.99
Manufacture of coke, refined petroleum products and nuclear fuel	sec08	5.56	4.92	-4.28	-8.76	-0.25	0.37	-0.79	-6.01	-0.78	-6.52	-4.28	-8.76
Manufacture of chemicals and chemical products	sec09	6.67	9.48	-4.34	-7.16	-0.47	-0.45	0.37	0.74	0.53	0.90	-4.23	-7.05
Manufacture of other non-metallic mineral products	sec10	4.67	4.43	-2.68	-2.49	-0.25	-0.16	0.21	0.04	0.22	-0.01	-2.73	-2.55
Manufacture of basic metals	sec11	5.67	5.00	-1.43	-2.97	-0.33	-0.31	5.55	4.73	5.64	4.80	-1.48	-3.10
Manufacture of fabricated metal products	sec12	10.80		-10.53		-0.30		0.75		0.82		-10.54	
Manufacture of machinery and equipment n.e.c.	sec13	10.80		-9.20		-0.05		0.21		0.08		-9.18	
Manufacture of motor vehicles, trailers and semi-trailers	sec18		7.35		-6.55		-0.16		-0.12		-0.17		-6.53
Manufacture of other transport equipment	sec19	10.80		-9.84		-0.24		0.16		0.17		-9.85	
Other manufacturing	sec20		2.69		-2.57		-0.15		0.09		0.03		-2.59

Note: If not indicated otherwise, all the variable are reported as percentage change compared with the baseline. Energy efficiency gains are reported with respect to the base year 2003.

Table 6: Effects of the implementation of the environmental agreements on the GHG emissions

Effects on the GHG emissions		2006	2007	2008	2009	2010	2011	2012
National GHG emissions		-0.25	-0.36	-0.51	-0.56	-0.78	-0.81	-0.83
National GHG emissions (kt)		132,723	135,099	137,461	140,158	140,596	142,773	145,039
National CO2 emissions		-0.58	-0.81	-1.07	-1.13	-1.49	-1.53	-1.55
National CO2 emissions (kt)		114,172	117,022	119,840	122,956	123,813	126,074	128,418
Regional CO2 emissions	wal	-0.15	-0.29	-0.39	-0.50	-0.61	-0.66	-0.71
Regional CO2 emissions	vla	-0.85	-1.16	-1.53	-1.57	-2.06	-2.10	-2.11
Regional CO2 emissions	bru	0.15	0.19	0.23	0.25	0.23	0.24	0.26
Regional CO2 emissions (kt)	wal	40,214	41,335	42,463	43,632	42,868	43,618	44,386
Regional CO2 emissions (kt)	vla	70,382	71,961	73,501	75,291	76,744	78,177	79,672
Regional CO2 emissions (kt)	bru	3,576	3,726	3,876	4,033	4,201	4,279	4,359
National CH4 emissions		0.01	0.01	0.01	0.01	0.01	0.01	0.01
National CH4 emissions (kt)		7,296	7,015	6,750	6,502	6,268	6,218	6,169
Regional CH4 emissions	wal	0.00	-0.01	-0.01	-0.02	-0.03	-0.04	-0.04
Regional CH4 emissions	vla	0.01	0.02	0.02	0.03	0.03	0.04	0.04
Regional CH4 emissions	bru	0.10	0.12	0.12	0.14	0.05	0.06	0.09
Regional CH4 emissions (kt)	wal	2,218	2,131	2,050	1,973	1,901	1,885	1,869
Regional CH4 emissions (kt)	vla	5,068	4,874	4,690	4,518	4,355	4,321	4,288
Regional CH4 emissions (kt)	bru	9	10	10	11	11	11	12
National N2O emissions		-0.14	-0.22	-0.35	-0.37	-0.61	-0.63	-0.62
National N2O emissions (kt)		11,255	11,062	10,870	10,700	10,515	10,481	10,453
Regional N2O emissions	wal	0.02	0.03	0.02	0.02	-0.01	0.00	0.00
Regional N2O emissions	vla	-0.23	-0.35	-0.53	-0.56	-0.89	-0.93	-0.92
Regional N2O emissions	bru	0.05	0.06	0.04	0.05	-0.05	-0.04	-0.02
Regional N2O emissions (kt)	wal	3,632	3,546	3,462	3,381	3,303	3,279	3,257
Regional N2O emissions (kt)	vla	7,517	7,406	7,293	7,199	7,086	7,073	7,065
Regional N2O emissions (kt)	bru	106	110	115	121	127	128	130

Note: If not indicated otherwise, all the variable are reported as percentage change compared with the baseline.

The CO_2 emissions on households' consumption increase up to 2012 due to their higher income level which stimulates consumption, including the consumption of energy inputs.

The measure by itself would not be enough to achieve the regional emission abatement targets established for 2008-2012. Moreover CH_4 emissions slightly rises (see table 6). N_2O emissions decrease by 0.62 per cent in 2012 at the national level due mainly to the decline in the Flemish region (see table 6).

5. Conclusions

Following the approval of the Kyoto Protocol by the European Union and the Burden Sharing Agreement among the member states, the *regional* impacts of various burden sharing formulas have been a major political and economic concern in Belgium. The Walloon and the Flemish governments have already introduced voluntary agreement schemes with major energy intensive sector, and some other policy measures are under discussion.

The only quantitative tool capable of producing results at the sectoral and regional level for Belgium is the dynamic regional and sectoral general equilibrium model GreenMod. We use the model to evaluate the effects of implementing such environmental agreements.

The adoption of the voluntary agreements by the manufacturing sectors proves to have positive economic effects, in terms of energy efficiency, GDP growth, employment and households' welfare. However, the GHG emissions decrease by only 0.83 per cent in 2012 compared to the baseline (2,087 kt of CO_2 equivalent), which is insufficient with regard to the Kyoto targets. Furthermore, the simulation shows that the targets established for the regional CO_2 emissions in the Belgium National Allocation plan cannot be achieved by the adoption of voluntary agreements alone. The federal and the regional governments will have to consider additional measures in order to comply with the EU Burden Sharing Agreement.

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Appendix A. Classification of the production sectors and commodities in GreenMod

Table A.1: Classification of the production sectors and commodities in GreenMod

NACE code	Name of the production sector or commodity	Commodity code in GreenMod	Production sector code in GreenMod
1, 2, 5	Agriculture, forestry, fishing	Com01	Sec01
10	Mining of coal and lignite; extraction of peat	Com02	Sec02
11	Extraction of crude petroleum and natural gas; incidental service activities		
	Extraction of natural gas	Com03	Sec03
	Extraction of crude petroleum	Com04	Sec04
12, 13, 14	Mining of uranium and thorium ores; mining of metal ores; other mining and quarrying	Com05	Sec05
15	Manufacture of food products and beverages	Com06	Sec06
21	Manufacture of pulp, paper and paper products	Com07	Sec07
23	Manufacture of coke, refined petroleum products and nuclear fuel		Sec08
	Coke oven coke	Com08	
	Petroleum coke	Com09	
	Nuclear energy	Com10	
	Gasoline	Com11	
	Heavy oil	Com12	
	Gas oil	Com13	
	Coke oven gas	Com14	
	Refinery gas	Com15	
	Other combustibles	Com16	
24	Manufacture of chemicals and chemical products	Com17	Sec09
26	Manufacture of other non-metallic mineral products	Com18	Sec10
27	Manufacture of basic metals	Com19	Sec11
28	Manufacture of fabricated metal products	Com20	Sec12
29	Manufacture of machinery and equipment n.e.c.	Com21	Sec13
30	Manufacture of office machinery and computers	Com22	Sec14
31	Manufacture of electrical machinery and apparatus n.e.c.	Com23	Sec15
32	Manufacture of radio, television and communication equipment and apparatus	Com24	Sec16
33	Manufacture of medical, precision and optical instruments, watches and clocks	Com25	Sec17
34	Manufacture of motor vehicles, trailers and semi-trailers	Com26	Sec18
35	Manufacture of other transport equipment	Com27	Sec19

Table A.1: Classification of the production sectors and commodities in GreenMod (continued)

NACE code	Name of the production sector or commodity	Commodity code in GreenMod	Production sector code in GreenMod
16-20, 22, 25, 36, 37	Other manufacturing	Com28	Sec20
40	Electricity, gas, steam and hot water supply		
	Production and distribution of natural gas	Com29	Sec21
	Production and distribution of nuclear electricity	Com30*	Sec22
	Production and distribution of non-nuclear electricity		Sec23
60, 61	Land transport; water transport; transport via pipelines	Com31	Sec24
62	Air transport	Com32	Sec25
63	Supporting and auxiliary transport activities; activities of travel agencies	Com33	Sec26
75	Public administration and defence; compulsory social security	Com34	Sec27
80	Education	Com35	Sec28
85	Health and social work	Com36	Sec29
41, 45, 50-52, 55, 64-67, 70-74, 90-93, 95	Other services	Com37	Sec30

*: Final user is consuming electricity regardless of its origin (nuclear or non nuclear)