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Impact of the EU Energy and Climate Package on the Belgian energy system and economy

Study commissioned by the Belgian federal and three regional authorities

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Abstract – In order to prepare for the negotiations on the EU Energy and Climate Package, the Federal Planning Bureau was asked by the Belgian federal and regional authorities to conduct a study on the impact of the January 2008 European Commission's proposal. In the course of this study, various scenarios were run. Next to a baseline, two main alternative scenarios were scrutinised: the *20/20 and 30/20 target scenarios*, standing for an EU reduction of respectively 20% and 30% of GHG emissions in the year 2020 compared to the level of 1990 and a 20% mandatory EU share of RES in Gross Final Energy Demand in 2020. The report then includes an analysis of the impact of both scenarios on the Belgian energy system and economy as well as on GHG emissions.

Jel Classification – Q4, C6, O2

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Executive Summary

In 2007 the European Union stepped up its energy and climate change ambitions to a new level. Based on several communications by the European Commission on an Energy and Climate Policy for Europe, the EU Council agreed to:

– An independent greenhouse gas (GHG) emission reduction commitment of 20% by 2020 compared to 1990 levels and an objective for a 30% reduction by 2020 subject to the conclusion of a comprehensive international climate change agreement,
– A mandatory 20% share of Renewable Energy Sources (RES) in Gross Final Energy Demand by 2020 for the EU as a whole including a 10% share of Renewables in transport for each Member State, and
– An improvement of energy efficiency by 20% compared to baseline levels by 2020.

The Council recognized that the implementation of these targets should be based on a combination of Community measures and on efforts to be undertaken by Member States. In January 2008 the European Commission came forward with an integrated Package of concrete proposals, including how efforts could be shared among Member States to achieve these targets (the so-called Energy/Climate Package). For GHG emissions, the proposal focuses on a 20% reduction target with possibilities and principles for an effort increase to a -30% scenario in case a comprehensive international climate change agreement is reached.

In order to prepare for the upcoming negotiations, the Belgian federal and three regional authorities collectively commissioned a study at the Federal Planning Bureau beginning of November 2007. This study would at first investigate possible arrangements for Belgium in the EU burden sharing scheme, and then focus on the impact of the Energy/Climate Package on Belgium's energy and economic system. By so doing, it would also shed a light on the scientific underpinning of Belgium's negotiating positions in the discussions on the Package.

This report presents a summary of this study and its results. It analyses a set of scenarios resulting from thorough consideration in the Steering Committee, a think tank brought to life to accompany and steer the work carried out by the Federal Planning Bureau. Next to a baseline, two main alternative scenarios are being scrutinised: the so-called *20/20* and *30/20 target scenarios*, respectively standing for a 20% and 30% reduction of GHG emissions at EU level in the year 2020 compared to the level of 1990 and an EU-imposed 20% share of RES in Gross Final Energy Demand in 2020. The report includes an analysis of the impact of either scenario on the Belgian energy system and GHG emissions (using the PRIMES and GAINS models) and a subsequent analysis of the broader macroeconomic impact of these objectives (using the HERMES model).

This report also provides a couple of sensitivity and complementary analyses which make it possible to evaluate the impact of flexibility.

The analysis of the impact of the Energy/Climate Package for Belgium starts with a *baseline* to which the GHG and RES target scenarios are compared. The baseline includes current trends and policies as implemented in Belgium by the end of 2006. For instance, the baseline takes as given the RES support policies existing at that time and the legal framework for the nuclear phase-out as decided in 2003. The baseline leads to GHG emissions increasing by 13.1% in 2020 compared to 2005 (i.e. a 26.1% increase in the ETS sector and a 3.7% increase in the non-ETS sector). The baseline leads also to a share of RES in Gross Final Energy Demand of 7.5% in 2020 compared to 2.1% in 2005. The share of RES in 2020 includes a share of 6.9% of biofuels in transport.

The *20/20 and 30/20 target scenarios* have been designed along the lines of the Energy/Climate Package of the European Commission, including those with respect to GHG and RES flexibilities.

More precisely, the *20/20 target scenario* (1) integrates a 15% reduction of GHG emissions in the Belgian non-ETS sector in 2020 compared to the level of 2005, (2) considers the effort performed by the Belgian ETS sector in the context of the emission cap set at EU level, (3) includes the Belgian target of 13% of RES in Gross Final Energy Demand and (4) takes into account the possibility to use CDM credits, to trade annual emission allocations with other EU countries and to reach part of the RES target in another Member State.

Because of the lack of specific quantitative targets for GHG emissions on the Member State level, the design of the *30/20 target scenario* is based on the best available knowledge as follows: (1) it assumes a 21% reduction target for GHG emissions in the Belgian non-ETS sector in 2020 compared to the level of 2005, (2) it considers that the additional effort performed by the Belgian ETS sector is determined by a more stringent ETS cap at EU level, and (3) it allows for additional CDM flexibility and intra-European emission trading. For RES, the design is similar to the one adopted in the *20/20 target scenario*.

Reducing GHG emissions and developing RES has an *impact on the evolution of the Belgian energy system*, not only on the structure and quantity of energy needs but also on the technological choices for energy production and consumption. The changes are driven by the so-called carbon and renewable values which influence the (energy) choices of the economic agents so that the defined GHG and RES targets are met.

Energy savings and *RES deployment* are the main responses of the Belgian energy system to the targets. In the *20/20 (30/20) target scenario*, final energy demand declines by 5.7% (6.3%) compared to the baseline in 2020. Its average annual growth rate falls back to 0.5% (0.4%) over the period 2005-2020 compared to 0.9% in the baseline. This is primarily due to *energy savings* and increased energy efficiency in transport as well as in the tertiary and residential sectors. Industry seems to be least affected by this decrease in final energy demand, what can be ascribed to the Belgian industry being already relatively energy efficient.

With the exception of RES deployment, very few *fuel substitutions* take place in the final demand sectors. This results from the already large share of natural gas which has the lowest carbon content among fossil fuels, from the almost unchanged competitive position of the different energy forms and from the fact that the evolution of the production (and therefore the energy forms) in the iron and steel sector is assumed to remain the same in all scenarios.

It is worth pointing out that energy savings concern not only fossil fuels, which experience higher prices proportionally to their carbon content, but also electricity. The *demand for electricity* grows by 1.3% per year on average over 2005-2020 in both scenarios compared to 1.6% in the baseline. This result reflects the fact that 2020 is a rather short deadline for the power generation sector to switch to new low-carbon generation techniques (e.g. carbon capture and storage facilities) in addition to RES. The share of *green electricity* increases to 19% in 2020 compared to 12% in the baseline. The already high share of natural gas in power generation in the baseline, the nuclear phase-out and electricity imports that are fixed exogenously also restrict the ways the power sector can adapt to the GHG emission reduction constraint. Higher fossil fuel prices induced by the carbon price and the RES development constraint lead to increases in the average cost of power generation in comparison with the baseline, which are assumed to be passed on to electricity prices.

On the positive side of the picture, the grouping of the GHG and RES targets leads to a more balanced *fuel mix in the power sector* in 2020 than would have otherwise been with the sole constraint on GHG emissions. The double target prevents a significant increase in the use of natural gas as a substitute for coal and avoids a dramatic drop in coal-based power generation because the presence of a renewable value implies lower carbon prices (compared to those required with a single GHG target) to achieve the same GHG emission constraint. In 2020, natural gas and nuclear energy each cover about 30% of the Belgian electricity supply whereas the share of coal remains close to its share in 2005 (i.e. roughly 10%). The fuel mix is similar in both target scenarios.

From a broader energy system perspective, the twin target induces a remarkable boost in the *development of RES*, which mostly concerns domestic resources, and so prevents the security of our future energy supply from deteriorating. Regarding the first effect, the share of RES reaches 12.3% of Gross Final Energy Demand in 2020, the deficit compared to the 13% proposal being closed by RES flexibility mechanisms. This share of 12.3% means an increase in RES production by 1.7 Mtoe (or 20 TWh) from baseline levels in 2020. As far as the *security of energy supply* is concerned, imports of all fossil fuels decrease compared to the baseline. This result waters down the claim of an increased dependency on natural gas imports. The growth of natural gas imports does not exceed 0.7% per year on average between 2005 and 2020.

The *20/20 target scenario* leads to a domestic reduction in *GHG emissions* by 0.5% in 2020 compared to 2005. Compared to the baseline in 2020 however, GHG emissions in Belgium are expected to be 12% lower. In the non-ETS, GHG emissions decrease by 9% in 2020 compared to the level of 2005 (and by 12% from baseline levels in 2020). Access to flexibility mechanisms is assumed to fill the gap with respect to the proposed -15% target. In the ETS, GHG emissions increase by 12% in 2020 compared to the level of 2005 (but decrease by 11% from baseline levels in 2020). This evolution is part of a cost-efficient allocation of the -21% target in the ETS at EU level. In the *30/20 target scenario*, the domestic GHG emission reduction amounts to 1.4% in 2020 compared to 2005 (and to 13% compared to baseline). Although the efforts made on the Belgian territory in both scenarios are very much alike, the amount of flexibility mechanisms used is very different.

The changes in the energy system and the reductions of non-energy related GHG emissions result in *economic costs*. The evaluation of the economic costs involves two complementary approaches. The first approach relies on the assessment of the direct cost which encompasses two components: (1) the direct cost related to domestic effort (i.e. energy equipment cost, fuel purchase cost, 'disutility' cost and non-CO_2 GHG mitigation cost) and (2) the cost related to flexibility and to distribution of auctioning rights in ETS. The second approach deals with the macroeconomic impact of the Package. The economic costs described hereafter are additional costs, compared to the baseline.

The *direct cost related to domestic effort* which encompasses the cost supported by the Belgian energy system and the cost resulting from mitigation measures for the non-CO_2 GHG is valued at 2.9 billion € in 2020 in the *20/20 target scenario*, and at 3.3 billion € in the *30/20 target scenario* (direct cost figures are in € of 2005).

The *total direct cost*, namely the direct cost of domestic effort plus the cost associated to the purchase of CDM credits and annual emission allocations in non-ETS, the cost of RES flexibility and costs linked with distribution of the auctioning rights in the ETS, mounts to 3.5 billion € in the year 2020 in the *20/20 target scenario* (i.e. 0.86% of the Belgian GDP in 2020). It was not possible to assess the total direct cost of the *30/20 target scenario* because of uncertainties on the use of CDM in the ETS sector in the international context surrounding the *30/20 target scenario* and therefore on the costs related to the distribution of auctioning rights.

Turning to the sectoral allocation of the direct costs related to the domestic effort, the *20/20 target analysis* shows that the transport sector takes the lead with 40%, followed by the residential sector (32%) and industry (26%), whereas the tertiary sector bears no additional cost compared to the baseline. In absolute terms, this means that in 2020 the transport sector bears an additional cost of 1.2 billion € compared to the baseline, while the cost for households and the industry would amount to 1 billion and 0.8 billion € respectively.

However, the direct cost does not account for the *feedback effects on the Belgian economy and its sectors*. From a macroeconomic perspective, one needs to take into account the changes in agents' behaviour and demand level resulting from the rise in costs and prices which the higher energy prices would imply. Once investments in energy efficient equipment and new technologies and additional public revenues generated for example by the auctioning of emission allowances are taken up, one might expect that the proposed targets accompanied by adequate recycling policies would have positive effects and therefore reduce the first order estimate of the economic cost provided by the direct cost.

To account for these feedback effects, the macro-sectoral model HERMES is used. HERMES takes as an input the carbon values calculated by the PRIMES model for each target scenario. The introduction of the carbon value implies an increase of energy products' prices, depending notably on the CO_2 content of these products (in 2020, the average increase in energy prices would lie between 12.7% and 13.4% with respect to the baseline, depending on the target scenario). For the ETS sector, the carbon value can be interpreted as the price of the EU allowances on the market. For the non-ETS sector, the carbon value is a measure in monetary terms of the stringency of the emission reduction constraints in this sector. It is to be interpreted as the price-signal needed to induce the corresponding emission reduction by the economic agents. Although it is supposed to reflect any kind of emission reduction policy or measure, in the HERMES simulations, it is assumed to be implemented through a carbon tax. HERMES then simulates the impact on the economy of each target scenario for which alternative assumptions have been made regarding the use of the potential public receipts (recycling).

Four recycling options are investigated, going from a "no recycling" option (all new and potential public revenues are used to reduce public indebtedness) to a "full recycling" option where all new and potential public revenues are used to reduce social contributions paid by employers. The two other options are a "partial recycling" and a "mixed recycling" policy. In the first case, the ETS sector revenues are recycled in the buildings and infrastructure sectors (for investments in the rational use of energy) to simulate the earmarking principle in the legislative proposal. In the second case, the ETS sector revenues are recycled in the buildings and infrastructure sectors, and the non-ETS sector revenues are recycled in reductions of social contributions paid by the employers.

The different HERMES simulations also account for a modification of the European economic context as the reduction targets defined in the Energy and Climate Package come within the scope of a European effort to be achieved by all Member States.

The results of the simulations depend on the extent of the new and potential public revenues recycling. Indeed, in the case of a "no recycling" option, real GDP would be reduced by 0.45% in 2020 in the *20/20 target scenario* (0.50% in the *30/20 target scenario*), as a consequence of diminishing exports and of a fall in domestic demand. This corresponds to a decrease in the average annual economic growth by 0.041 percentage points over the 2010-2020 period (0.045 in the *30/20 target scenario*). Employment would also be negatively affected by the policy, with a loss evaluated at about 16000 jobs in the *20/20 target scenario* and at about 17000 jobs in the *30/20 target scenario*. On the other hand, if a "full recycling" option of the new and potential public revenues is selected, the impact on GDP of the increase in energy prices would be quite limited. The reduction in real GDP with respect to the baseline would then reach 0.07% only in 2020 in the *20/20 target scenario*, and 0.12% in the *30/20 target scenario*, meaning a slowdown of the average annual economic growth by 0.006 percentage points in the *20/20 target scenario* and 0.011 percentage points in the *30/20 target scenario*. Furthermore, the "full recycling" policy would have a positive effect on employment, which would be stimulated by the reduction of the wage costs per worker resulting from the reduction in social security contributions paid by the employers. In the *20/20 target scenario*, about 25000 jobs would be created in 2020 and the increase would amount to about 26000 jobs in the *30/20 target scenario*. The results of the two recycling options described above indicate a possible range of the impacts on the Belgian economy; the actual impacts could lie in between. Different subsectors of the economy are affected differently.

Energy savings and RES deployment, the two main responses to the proposed Energy/Climate Package for Belgium, are *challenging economic, industrial and societal issues*. Both areas will bring about costs, but also opportunities. They will however require quick, intensive and steady policy action in order to meet the objectives.

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1. Introduction

1.1. Context

In **2007** the European Union stepped up its energy and climate change ambitions to a new level. Based on several communications by the European Commission on an Energy and Climate Policy for Europe[1], the EU Council agreed to:

- an independent greenhouse gas emission reduction commitment of 20% by 2020 compared to 1990 levels and an objective for a 30% reduction by 2020 subject to the conclusion of a comprehensive international climate change agreement
- establish a mandatory 20% share of Renewable Energy in Gross Final Energy Demand by 2020 for the EU as a whole including a 10% share of Renewable Energy in Transport for each Member State
- improve the energy efficiency by 20% compared to baseline levels by 2020.

The Council recognized that the implementation of these targets should be based on a combination of Community measures and on efforts to be undertaken by Member States. It requested the Commission to prepare a proposal to implement this Package.

In **January 2008** the European Commission came forward with an integrated Package of concrete proposals, including how efforts could be shared among Member States to achieve these targets. The proposal concerns the -20% scenario while it also puts forward possibilities and principles for an increase to the -30% scenario in case a comprehensive international climate change agreement is reached.

The emission reductions for sectors under the EU ETS are addressed at Community level. The emission reductions to be obtained in the non-ETS sectors are shared among the Member States on the basis of a GDP per capita distribution key[2]. The proposal for the distribution of the renewable energy target is based on a combination of a flat rate approach and the GDP per capita criterion[2].

The Commission's proposal is being discussed in the European Parliament and the European Council with the objective to come to an agreement about this integrated Package by the end of 2008 and have it signed at the beginning of 2009.

1 "Limiting Global Climate Change to 2 degrees Celsius"; "Renewables Roadmap" and "European Strategic Energy Technology Plan"

2 The European Council (8-9 March 2007) decided that a differentiated approach to the contributions of the Member States is needed reflecting fairness and transparency as well as taking into account national circumstances.

1.2. Objectives

In order to prepare for and underpin the upcoming negotiations on the Energy and Climate Package, the federal and three regional authorities collectively commissioned two studies at beginning of November 2007. The first would focus on the negotiations for the -20% scenario and the second on the -30% case. Both studies use the same approach and models and are therefore clearly interlinked. The results of both studies are discussed in this report.

The objectives of the study changed in the course of the project period as a result of more insights in the European Commission's approach to the burden sharing and as a result of the change in focus of the negotiations, shifting from an overall approach to specific elements of the Package (e.g. flexibility issues).

Since no information on the approach by the European Commission was available at the time of the start of the project, the objective was to study the impact of different burden sharing approaches for the EU GHG reduction targets (in both the -20% and -30% scenarios) and renewable energy objectives on the Belgian energy system and economy.

The first scenario studied then was the **reference burden sharing arrangement,** a burden sharing based on equal marginal abatement costs among Member States as this was the Belgian position at the Spring Council of 2007.

The conclusions of the Spring Council of 2007 state that the burden sharing should take the following principles into account:
- fairness and equity
- national circumstances
- cost-efficiency.

Thereafter the impact of burden sharing arrangements that differ from the reference burden sharing arrangement is analysed. The Steering Committee[3] decided to simulate this by alternative GHG reduction targets in both ETS and non-ETS different from those resulting from the reference burden sharing arrangement.

At the **end of November 2007**, the European Commission held bilateral consultations with the Member States and revealed the specific proposal for the EU27 and the Member States. Instead of applying GHG reductions and RES objectives in an arbitrary way as was first decided, the Steering Committee then decided to calculate the impact of the Commission's proposal compared to the reference burden sharing scenario. The information received from the European Commission further specified that limited use of CDM in non-ETS would be allowed. It was not clear however how CDM use by ETS sectors would be dealt with.

3 For a definition of the Steering Committee, see Glossary (chapter 7).

In early January 2008, leaked documents about the legislative proposals gave further insight in the European Commission methodology which resulted in adjustments for the macroeconomic impact calculation of CDM-use in the variant that simulates the European Commission proposal.

At the **end of January 2008** the entire proposal and its Impact Assessment were published. The focus of the study then shifted from the calculation of the impact of different burden sharing arrangements to the scientific underpinning of Belgium's negotiating positions in the discussions on the Package. The main focus has then become the assessment of the impact of flexibility and redistribution mechanisms to make direct costs of the Package for Belgium more comparable to the direct costs of comparable Member States[4], while preserving the environmental integrity and overall balance in the Package. This implies that the impact of the following negotiating positions is evaluated[5]:

- impact of higher CDM limit for Belgium (more than 3% of 2005-emissions) for the realisation of the non-ETS target;
- impact of trade in (excess) annual emission allocation in the non-ETS sector (here referred to as AAUs[6]);
- impact of trade in Guarantees of Origin[7] (GO) on the realisation of the renewable energy target;
- sensitivity analysis regarding the price of CDM.

The impact of other negotiating positions cannot be assessed quantitatively due to the limitations of the approach and the models used.

4 To set the stage, in the Impact Assessment Belgian direct costs are calculated as being 0.70% of its 2020 GDP, whilst the EU15 mean is 0.50% and the EU27 mean reaches 0.45%.

5 The report nevertheless does not discuss each and every negotiating position (translated into a separate scenario) in as much detail. It principally analyses the three main scenarios (baseline, *20/20* and *30/20 target scenario*), other positions and scenarios are rather briefly described in the text or further looked into in the Annex.

6 Under the Kyoto Protocol annual emission allocation is referred to by so-called Assigned Amount Units. These can be traded among parties. In the unilateral agreement there are officially no AAUs but for easy reference the trade in annual emission allocation in the non-ETS sector is in this report referred to as trade in AAUs.

7 The ultimate mechanism for RES trade has not been officially decided upon yet and remains a largely opaque subject. In order to designate the flexibility mechanisms that relate to trade in RES between Member States, we will use the term GO's in this report. This does not, however, privilege any choice whatsoever or any liking whatsoever in the final instrument to be used in RES trade, be it Guarantees of Origin, transfers between national energy balance sheets, joint projects between Member States or any other instrument.

2. Methodology & key assumptions

This study aims at elaborating and analysing greenhouse gas' (GHG) and renewable energy sources' (RES) target scenarios for Belgium in a European context, using the PRIMES model developed by ICCS/NTUA and the GAINS model of IIASA (for non-CO_2 GHG). The HERMES model of the FPB will then be used to assess the macroeconomic impact of these target scenarios.

2.1. Methodology

Reducing GHG emissions and developing renewable energy have an impact on the evolution of the (Belgian) energy system, not only on the structure and quantity of energy needs but also on the technological choices for energy production and consumption. In order to evaluate this impact the (European) energy model PRIMES is used. The PRIMES model covers the energy and process related emissions of CO_2.

Non-CO_2 GHG emissions are modelled by using the GAINS[8] model of IIASA. In GAINS, the emission reduction possibilities are modelled through marginal abatement cost curves that are defined per type of non-CO_2 GHG (i.e. CH_4, NO_2 and F-gases) and per country. These curves, along with CO_2 reduction possibilities quantified by using the PRIMES model, are combined for constructing the GHG and RES target scenarios.

Two versions of the PRIMES model are used in the study:
- PRIMES-EU[9] is run in combination with GAINS to assess the cost efficient allocation amongst all 27 Member States.
- PRIMES-BE is used in combination with the marginal abatement cost curves for Belgium for the non-CO_2 GHG (taken from GAINS) for subsequent runs: by using this methodology, we can evaluate the specific impacts on the Belgian energy and economic system. In order to take the EU-context into account, carbon and renewable values used in the PRIMES-BE-model are read on the EU-MAC-curve or are the result of related PRIMES-EU runs (as assessed in the European Commission's Impact Assessment).

The macroeconomic impact of the different scenarios is calculated by means of the macroeconometric HERMES model[10]. HERMES takes as an input the carbon values calculated by the PRIMES model for each target scenario. The introduction of the carbon value implies an increase of energy prices, depending notably on the CO_2 content of the various energy forms. For the ETS sector, the carbon value can be interpreted as the price of the EU allowances on the market. For the non-ETS sector, the carbon value is a measure in monetary terms of the stringency of the

8 A short description of GAINS is given in section 6.7.2.
9 PRIMES-EU is not a model as such; it is a linkage of all 27 national models. The PRIMES model is briefly described in section 6.7.1.
10 More information about the HERMES model is available in section 6.7.3.

emission reduction constraints in this sector. It is to be interpreted as the price-signal needed to induce the corresponding emission reduction by the economic agents. Although it is supposed to reflect any kind of emission reduction policy or measure, in HERMES it corresponds to the implementation of one or several revenue-generating policies, such as a carbon tax.

The auction of EU ETS allowances provides new revenues for the country. Additional receipts may potentially also be captured in the non-ETS sector. It is only the case if the government succeeds in implementing such revenue-generating instruments in this sector.

In order to be coherent with PRIMES' assumptions and results, some variables in the HERMES version of April 2007 were adapted. The changes relate to the evolution of international prices and the potential export markets (simulated by the European macro-sectoral model NEMESIS-EU15) as well as the structure of the electricity production park. HERMES simulates various assumptions as to how potential public receipts resulting from a GHG reduction policy are recycled.

Four recycling options are investigated:

– No recycling policy: the new public revenues are not recycled but are used to reduce public debt.
– Partial recycling policy: the ETS sector revenues are recycled in the buildings and infrastructure sectors[11] (for investments in the rational use of energy).
– Mixed recycling policy: the ETS sector revenues are recycled in the buildings and infrastructure sectors, and the non-ETS sector revenues are recycled in reductions of social contributions paid by employers.
– Full recycling policy: all public revenues (ETS + non-ETS) are recycled in reductions of social contributions paid by employers.

The first and fourth recycling policies are extensively discussed in the main report as they provide a range of the impacts on the Belgian economy. The partial and mixed recycling policies are dealt with in Annex 6.6. Note that the partial recycling policy is likely to occur if the country is unable to implement revenue-generating policies in the non-ETS sector.

The third and fourth recycling options are calibrated to be tax neutral for the public authorities[12], meaning that new public revenues that are generated are exactly offset by tax reductions elsewhere[13].

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11 The recycling of ETS sector revenues to the sectors of buildings and infrastructure is a simulation of the earmarking principle stated in Article 10, §3 of the legislative proposal of the Commission. Note that this option corresponds to 100% use of the revenues while the original text proposed 20% earmarking.

12 The model results do not depend on which Belgian authority (regional or federal governments) collects and/or spends the new public revenues.

13 On the contrary, the first and second policy options are not tax neutral.

2.2. Key assumptions

The methodology and general working assumptions used in the PRIMES model have already been elaborately explained in other recent publications. Interested readers are therefore kindly referred to the following publications: European Commission, DG TREN (2008), *European Energy and Transport, Trends to 2030 – Update 2007*, prepared by NTUA with the PRIMES model; Capros et al. (2008), *Model based Analysis of the 2008 EU Policy Package on Climate Change and Renewables*, Report to the European Commission, DG ENV, pp. 5-10 and pp. 25-47 and Commission of the European Communities (2008), *Annex to the Impact Assessment*, Commission Staff Working Document.

The following part deals with hypotheses specific to the Belgian context, in particular its macroeconomic and demographic indicators, its energy policies (nuclear phase-out, incentive systems for renewable energy forms and CHP) and the definition of the Belgian ETS sectors[14].

2.2.1. Economic activity and demography

In order to prepare energy projections, hypotheses on the evolution of the national macroeconomic and demographic situation are indispensable[15]. Table 1 depicts the absolute values of these indicators, next to their average growth rate on an annual basis. First, projections of the total number of people living on Belgian soil[16] and the average household size for the period 2005-2020 are given, followed by the GDP and the average consumption expenditure of households. Subsequently, the Gross Value Added is depicted, first in total, then split up by (sub)sector.

14 (General) energy price projections (which are the same across all EU27 countries) are given in Annex 6.1 as well as some key elements of the quantitative evaluation of the effect of higher fossil fuel prices on the assessment of the Energy/Climate Package performed by NTUA (see Capros, 2008).

15 Demographic and macroeconomic assumptions are described more extensively in DG TREN (2007), *European Energy & Transport, Trends to 2030-Update 2007*. The principal sources of these hypotheses are Eurostat, Global Urban Observatory and Statistics Unit of UN-HABITAT, Economic and Financial Affairs DG of the European Commission, Member States' stability programmes and the results of the GEM-E3 and PRIMES models.

16 In the meantime, the Federal Planning Bureau together with ADSEI have published an update of their joint demographic forecasts for Belgium (April, 2008). The average annual growth rate of the Belgian population between 2005 and 2020 according to this new demographic forecast is 0.7%. For more information, see http://www.plan.be/publications/Publication_det.php?lang=nl&TM=46&IS=63&KeyPub=650.

Table 1: Macroeconomic and demographic assumptions for Belgium, 2005-2020

	2005	2010	2015	2020	20//05
Population (in millions)	10.446	10.583	10.674	10.790	0.2%
Number of households (in millions)	4.445	4.642	4.808	4.995	0.8%
Household size (inhabitants per household)	2.35	2.28	2.22	2.16	-0.6%
Consumption expenditure of Households (in € of 2005 per capita)	14890	16408	17880	19191	1.7%
GDP (in 000 millions € of 2005)	299	336	374	409	2.1%
Gross value added (in millions € of 2005)	264966	295673	327912	358615	2.0%
Industry	51511	56165	61317	65985	1.7%
Iron&Steel	2887	2947	3051	3124	0.5%
Non-ferrous metals	932	946	987	1026	0.6%
Chemicals	10933	12244	13667	15020	2.1%
Non-metallic minerals	2369	2611	2834	3018	1.6%
Pulp, paper and printing	3753	4158	4584	4973	1.9%
Food, drink and tobacco	5728	6307	6859	7307	1.6%
Textiles	2513	2362	2292	2274	-0.7%
Engineering	17782	19325	21285	23023	1.7%
Other industries	4613	5265	5757	6221	2.0%
Construction	13108	14131	15208	16271	1.5%
Tertiary	191816	216659	242237	266824	2.2%
Market services	77699	89802	100771	111551	2.4%
Non market	56099	61686	67669	72775	1.8%
Trade	54080	61030	69448	78000	2.5%
Agriculture	3939	4141	4349	4498	0.9%
Energy sector	8531	8718	9150	9535	0.7%

Source: EC-DG TREN (2008)
//: average annual growth rate

2.2.2. Policy context

The baseline integrates adopted policies for the different economic actors as known at the end of 2006. The inherent baseline assumption is that all current policies and those in the process of being implemented by the end of 2006 will proceed in the future. It is not assumed, however, that the indicative targets, as set out in various EC Directives, are necessarily met. The numerical values for these indicators are outcomes of the model; they reflect policies rather than targets. In other words, the baseline:

– integrates the Belgian Law on the progressive phase-out of nuclear energy. The baseline thus takes into account the decommissioning of nuclear power plants once they turn 40, in accordance with the Law on the progressive phase-out of nuclear energy for industrial electricity production which has been passed on January 31, 2003[17].
– takes up the system on green and CHP certificates. In agreement with the European Directive on the promotion of electricity generation from renewable energy sources, the Belgian Regions have decided to make use of green certificates. As regards combined heat and power

17 Belgian Official Journal (Belgisch Staatsblad, Moniteur Belge or Belgisches Staatsblatt), February 28, 2003, pp. 9879-9880.

(CHP) technologies, the Regions have fixed regional objectives in order to stimulate the production of electricity on the basis of CHP. In PRIMES, these supporting policy instruments for renewable energy forms are modelled through a subsidy on investment. This is a simplified manner to model the very complex national incentive regimes and reckon with the fact that one cannot exactly model the certificate market. The subsidies are then calibrated in such a way that (1) the Belgian objective of RES-electricity in 2010 for which the green certificates' system is introduced will be met; (2) they diminish through time so as not to overdraw the budgetary constraint. Indeed, if the subsidy rates would stay equal, the cost of subsidising would become prohibitive because the RES volume increases every year. Every year, the subsidies are calibrated in such a way that the total envelope stays more or less constant to its 2006 level; the resulting decrease per renewable energy form then depends on the maturity of the technology: as such, the subsidies for onshore wind decline the fastest followed by offshore projects, whilst the subsidies for solar PV still stay relatively high until 2020.

– In the baseline, the reality of the current National Allocation Plans (NAP) is taken into account through the introduction of a carbon value (CV) of 20 €/tCO_2 in 2010, gradually reaching 22 €/tCO_2 in 2020, the purpose of which is to mimic the characteristics of this system.

2.2.3. Definition of ETS

In the analyses performed by the National Technical University of Athens (NTUA), following sectors are considered to be part of the ETS-sector: aviation, power and heat generation (including the production of steam in industrial boilers), iron and steel, non-ferrous metals, the chemical sector, non-metallic minerals and paper and pulp, as well as non-energy (process) CO_2 emissions.

3. Baseline

Before going into the specificities of the GHG and RES target scenarios into detail, a concise analysis of the baseline is provided. The baseline and its underlying assumptions are of utmost importance for the purpose of this study as they form the basis for subsequent benchmarking of the target scenarios.

The baseline simulates current trends and policies as implemented in Belgium at the end of 2006. While informative about the development of policy relevant indicators such as the renewables share in 2010, the baseline does not assume that indicative targets, as set out in the Directives, will necessarily be met[18]. The numerical values for these indicators are outcomes of the model; they reflect implemented policies rather than targets. This also applies for CO_2 and GHG emissions. The baseline thus describes what the Belgian energy future could look like if no additional actions are taken.

In what follows, the baseline, as agreed in the Steering Committee, will be described for a selection of key energy and emission indicators. This baseline differs in a few respects from the baseline for Belgium as published by DG TREN (European Commission, Directorate-General for Energy and Transport (2008), *European Energy and Transport, Trends to 2030 – Update 2007*, prepared by NTUA with the PRIMES model). The differences are outlined in Annex 6.2.

3.1. Energy trends

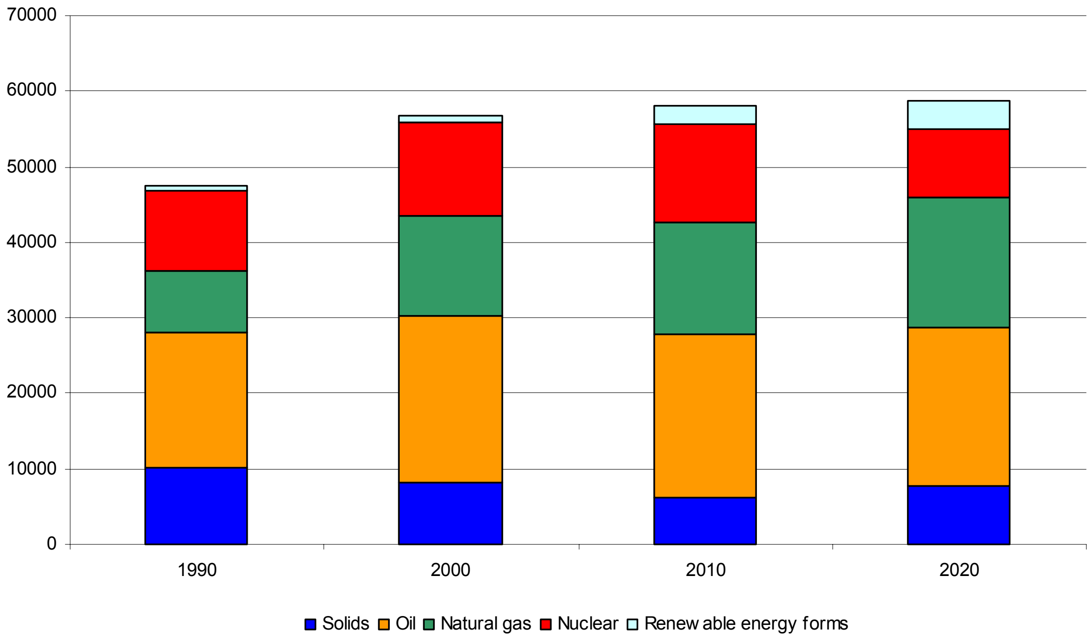
3.1.1. Gross Inland Consumption

The first indicator scrutinized is the Gross Inland Consumption (GIC) or Primary Energy Demand. The GIC is an indicator that describes a nation's total energy consumption and that consists of primary production (energy sources that are exploited on the nation's soil, e.g. wind and hydro) and net import (energy sources that are imported by the country, e.g. oil). The figure below shows that the Belgian GIC follows a slowed down growth path. In 1990, it reached 48 Mtoe. Between 1990 and 2000, fast growth set in. After 2000, the surge levels off and by 2020, GIC reaches 59 Mtoe.

Throughout the period, solids loose much of their relative weight (from a share of 22% in 1990, they fall down to 13% in 2020). Nuclear energy shares this loss: its part in GIC dives from almost a quarter in 1990 to 15% at the end of the period. Meanwhile, natural gas manages to pick up the lost shares and is able to expand from 17% to 29%, together, but to a far lesser extent, with renewable energy sources, which, in 2020, represent 6% of GIC, up from 2% in 1990.

18 As a quick guide, some baseline model outcomes and their respective targets are given: the Belgian RES-E contribution in 2010 reaches 8.5% (so exceeding the 6% target), the Belgian biofuels' share in 2005 attains 0.0% (the target being set at 2%) and is 2.1% in 2010 (the target being 5.75%).

Figure 1: Gross Inland Consumption by fuel (ktoe), baseline, evolution



Source: PRIMES

Next, the GIC (or Primary Energy Demand) is shown in relation to some other parameters. We see that, since the Belgian GDP grows steadily[19], the energy intensity (the ratio between GIC and GDP) decreases. In other words, the consumption of energy does no longer go hand in hand with the growth in economic activity, since concepts of energy efficiency have permeated into industrial and other processes. Although energy intensity decreases, it is worthwhile mentioning that Belgium is (and stays) an energy intensive country. The share of energy costs as percentage of GDP ranks amongst the highest in the EU15, caused by the relatively energy intensive national industry and the apparently elevated energy consumption of Belgian households and tertiary sector.

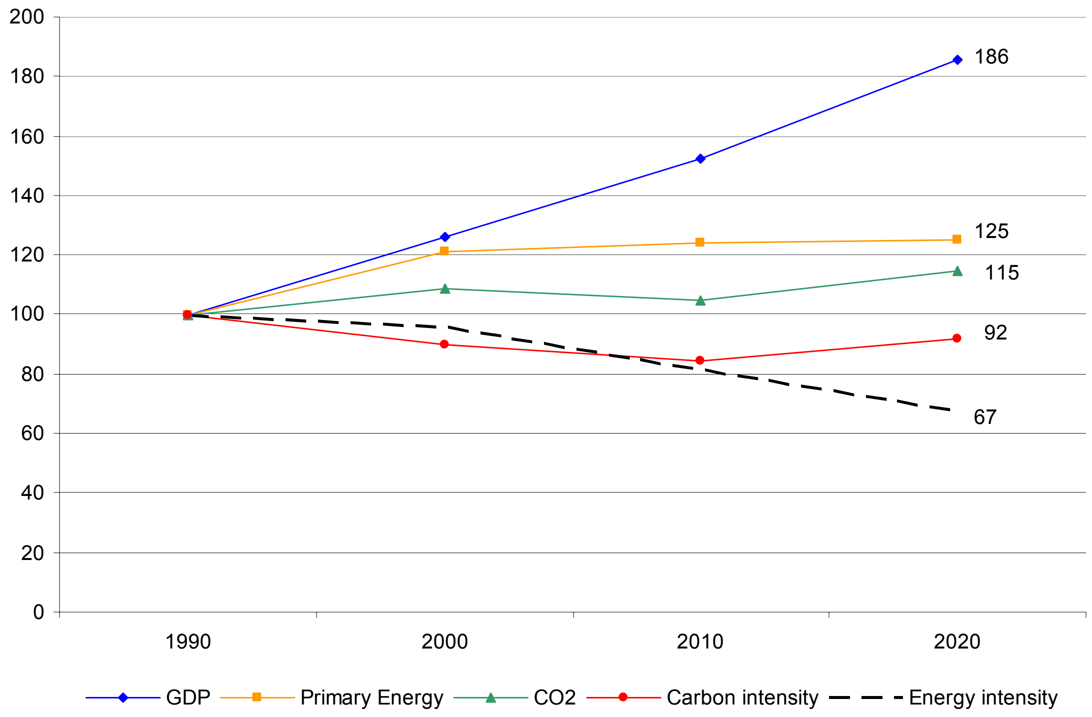
As far as the residential sector is concerned, the energy consumption per household is high in Belgium (compared to other EU15 Member States). This is principally due to an old(er) residential building stock. Investment cycles in residential are often longer than in other sectors (around 20 to 30 years) and thorough (energy) renovation is estimated to happen only when a dwelling is sold. The high energy intensity of the residential sector in Belgium compared to EU15 averages is thus to a large extent the result of a historical evolution. Notwithstanding that, several studies have pointed to the existence of an important energy saving potential in the Belgian building sector, but some specific structural barriers to the realisation of this potential seem to block its exploitation (in the short term). The situation in Belgium can be summarized as follows:

19 The average annual growth rate between 1990 and 2020 is 2.1%.

- Belgium has a comparatively low share of public (social) housing (7% of total housing stock, source: http://www.iut.nu/EU/HousingStatistics2004.pdf). This is important since it is easier for a government to steer renovation in this sector;
- Belgium possesses a scattered building stock: not many blocks of flats (4% of residential buildings) but a vast majority of detached ("quatre façades") houses (http://economie.fgov.be/barometers/ecodata/home_nl.htm); in terms of individual dwellings, flats and studio flats make up 23% of the total number of dwellings (Centrale Raad voor het Bedrijfsleven, 2005);
- Belgium is characterized by a long occupation of buildings: owners usually renovate only once during their occupancy (approximately 68% of Belgian dwellings are owner-occupied (http://www.iut.nu/EU/HousingStatistics2004.pdf));
- In Belgium, only 0.5 to 1% of all buildings is renovated each year (Centrale Raad voor het Bedrijfsleven, 2005) of which only a very small share is completely demolished and rebuilt.

Finally, carbon intensity, together with CO_2 emissions, follow a U-shaped path. Until the year 2010, a decreasing trend can be noticed, followed by a rise up to 2020 and beyond. The major cause is the nuclear phase-out as stipulated by law and the subsequent replacement of base load nuclear plants by coal (and gas) fired power plants.

Figure 2: GDP, primary energy demand, CO_2, energy and carbon intensity, baseline, evolution (1990=100)



Source: PRIMES, EC-DG TREN (2008)

3.1.2. Final Energy Demand

Zooming in on the FED (Final Energy Demand, i.e. the energy consumption of industry, households, the tertiary sector (including agriculture) and transport), we see that between 2005 and 2020, the FED increases by 14% (or an average annual growth rate of 0.9%). All energy forms grow, with the exception of oil, which stabilises. The surge in solids is due to the specific assumptions in the iron and steel production[20]. The oil status quo is in fact the sum of two opposite movements: a rising demand in transport and a declining oil consumption for heating purposes. Natural gas has already largely found its way in final demand and is mainly used for cooking and heating. The "other" energy forms, being renewable energy sources like biomass and solar thermal, develop the most, but represent the smallest share in total.

In terms of final demand sectors, industry occupies the largest share in both years. By the year 2020, the residential sector loses its second place to transport, a sector that experiences considerable growth over the projection period. Demand in the tertiary sector also increases significantly over the projection period, but in the year 2020, it only represents 14% of the total Final Energy Demand.

Table 2: Final Energy Demand by energy form and sector, baseline, year 2005 and 2020

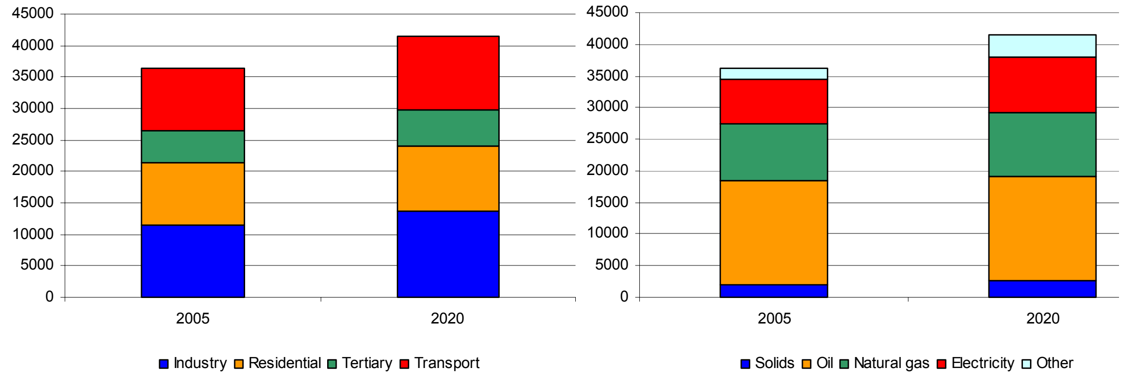
	2005		2020		Difference 2005-2020	
	ktoe	share	ktoe	share	ktoe	%
Solids	2052	6%	2723	7%	671	33%
Oil	16443	45%	16289	39%	-153	-1%
Natural gas	9003	25%	10116	24%	1113	12%
Electricity	6894	19%	8880	21%	1985	29%
Other	1930	5%	3379	8%	1450	75%
Industry	11523	32%	13705	33%	2182	19%
Residential	9914	27%	10442	25%	528	5%
Tertiary	5005	14%	5708	14%	703	14%
Transport	9880	27%	11532	28%	1652	17%
Total	*36321*		*41386*		*5065*	*14%*

Source: PRIMES, own calculations

The two figures below visualize the information given in Table 2 above: they depict the evolution of the FED between 2005 and 2020, subdivided according to sector or energy form.

20 See also Annex 6.2.

Figure 3: Final Energy Demand (ktoe), baseline, year 2005 and 2020



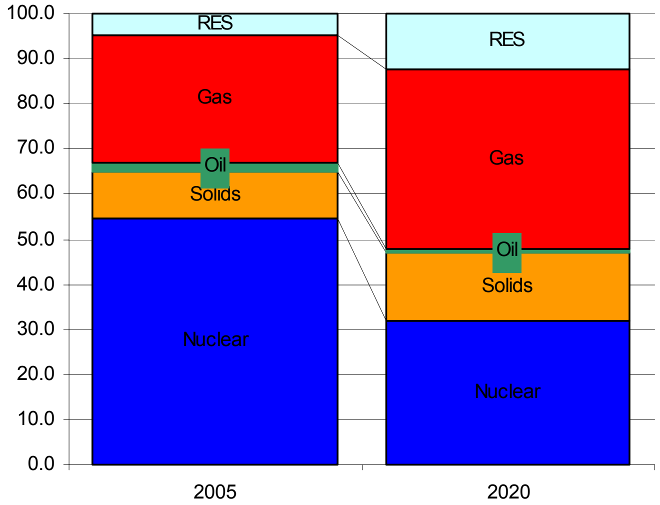
Source: PRIMES

3.1.3. Power generation

Turning to the power generation sector, a first indicator of interest is the evolution of the electricity demand. In 2005, called-up electrical power[21] ("énergie appelée") reached 88 TWh, in 2020 under baseline assumptions, 112 TWh will be consumed. This boils down to an average annual growth of 1.6%.

To satisfy demand, production has to follow[22]. The breakdown of the net electricity generation is depicted in the figure below. A significant change in shares can be noticed: more gas and RES are used, the share of solid fuels increases somewhat, while that of both oil and nuclear energy declines.

Figure 4: Net electricity generation (%), baseline, year 2005 and 2020



Source: PRIMES

21 This is the net electricity consumption plus the grid losses.

22 Electricity demand can also partially be met through (net) imports. These are however set exogenously and do not change according to the scenario: they amount to 5.9 TWh in 2020, compared to 6.3 TWh in 2005. The exogenous levels of electricity imports are based on the best knowledge of Member State policy and national Transmission System Operator's plans at the end of 2006.

The above evolution (level and structure) translates into an increase in the average cost of power generation by 18% between 2005 and 2020 (see Table 32 in annex 6.5.1). Furthermore, total investment expenditure in power generation between 2006 and 2020 is estimated at about 9.2 billion € (in € of 2005). Investment expenditure encompasses the replacement of existing plants that are decommissioned and additional production capacities required by the increase in electricity demand.

Zooming in on power generation based on renewable energy sources, the table below summarizes net power generation and inherent capacity for the 4 sources of renewables (hydro, wind, biomass & waste[23] and solar PV). With the currently implemented or approved policies (green certificates, investment subsidies, etc.), the net installed RES power capacity grows from a rather low 800 MW in 2005 to approximately 4000 MW installed in 2020; subsequent electricity generation based on RES grows from 3900 GWh in 2005 to 13200 GWh in 2020. This means that the share of RES in total electricity production increases from a 4.7% share in 2005 to 12.4% in 2020. The power capacity grows a bit faster than the production due to the intermittent nature of (some of) the renewables. In 2020, the largest capacity will be provided by wind energy, with total wind capacity estimated to be 2228 MW, of which 1250 MW onshore and 979 MW offshore.

Table 3: RES power capacity (MW) and electricity generation (GWh), baseline, year 2005 and 2020

	Net power capacity (MW)		Net electricity generation (GWh)	
	2005	2020	2005	2020
Hydro	102	108	280	362
Wind	167	2228	227	5334
Biomass and waste	551	1547	3375	7403
Solar PV	2	93	1	71
Total	822	3976	3883	13169

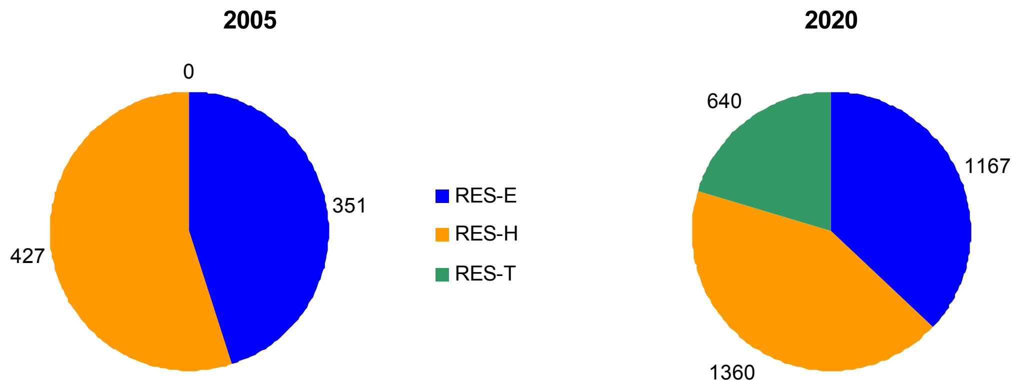
Source: PRIMES

3.1.4. RES in Gross Final Energy Demand

The upcoming European Directive on renewable energy sources subscribes to a 20% share of renewable energy in Gross Final Energy Demand[24] by 2020 for the EU as a whole (including a 10% share of renewable energy in transport for each Member State). For Belgium, this boils down to a 13% share, following a flat rate increase combined with an equity approach[25]. In the baseline, nonetheless, without the adoption or implementation of any additional incentives or actions by the end of 2006, we see that we are still a long way from reaching this objective. Starting from an absolute amount of 780 ktoe (9050 GWh) of RES in 2005, we arrive at 3200 ktoe (36800 GWh) by the year 2020. Expressed in percentage of Gross Final Energy Demand, this amounts to 7.5% in 2020. The figure below shows the split of RES in Gross Final Energy Demand according to its final use (heating and cooling, electricity and transport or RES-H, RES-E and RES-T).

23 An adequate definition of biomass and waste is given in the Glossary (see part 7).
24 A definition of (Gross) Final Energy Demand (as well as Gross Inland Consumption) is provided in the Glossary.
25 For more details, see Commission of the European Communities, Commission Staff Working document, *Annex to the Impact Assessment*, January 2008.

Figure 5: RES in Gross Final Energy Demand (ktoe), baseline, year 2005 and 2020



Source: PRIMES

The expansion in the share of biofuels is remarkable: it rises from non-existent (0 ktoe in 2005) to 640 ktoe in 2020. However this sharp rise is not sufficient to meet either the 2010 target of 5.75% or the 2020 target of 10%, as the share of biofuels only reaches 2.1% in 2010 and 6.9% in 2020.

3.2. Emission trends

According to PRIMES calculations based on Eurostat energy balances, Belgium emitted 117.7 Mt of CO_2 in 2005. This figure includes CO_2 emissions from international aviation and non-energy related CO_2 emissions. As far as non-CO_2 GHG emissions are concerned, GAINS reports 23.6 Mt of CO_2-equivalent in 2005. Summing up these two figures leads to 141.3 Mt of CO_2-equivalent for the GHG emissions in Belgium in 2005 (see Table 4). This data deviates from that reported in the last GHG emission inventory of March 2008 (i.e. 145.9 Mt) by 3.2%. This discrepancy results, on the one hand, from differences in energy statistics, and on the other, from changes in the reported data for the year 2005 (GAINS is based on inventory data of April 2007). The former diverging factor has been well known for several years. At this stage, however, we are unable to solve this problem. We chose to work with the PRIMES data and acknowledge that there is a difference with the officially reported emission data.

Table 4: GHG emissions in Belgium, baseline

	1990 (Mt CO_2 eq.)	2005 Mt (CO_2 eq.)	2020 (Mt CO_2 eq.)	2020 vs. 2005 (%)
All GHGs	142.2	141.3	159.7	13.1
All CO_2	115.5	117.7	133.2	13.1
ETS sectors		59.0	74.4	26.1
ETS without aviation		55.2	68.6	24.3
Aviation		3.8	5.8	52.0
Non-ETS sectors		82.3	85.3	3.7
Energy related non-ETS		58.7	58.7	0.1
Non-CO_2 GHGs	26.7	23.6	26.6	12.6

Source: PRIMES, GAINS, NTUA

NB: The model based emission data differ from the emissions officially reported to the UNFCCC. However, the European Commission uses the model results only to get insight into its energy-climate policy. The resulting percentages are, at the end, applied to the officially reported data for the determination of maximum emission levels in 2020.

Table 4 also shows that the ETS sector accounts for 42% of the total GHG emissions in 2005.

Under baseline assumptions, total GHG emissions in Belgium are projected to increase by 13% in 2020, compared to 2005. The evolution is fairly limited (+4%) in the non-ETS sector whereas the increase is significant in the ETS sector (+26%). The increase in the non-ETS sector comes essentially from non-CO_2 GHG emissions while energy related CO_2 are expected to remain at their 2005 level. The evolution in the ETS sector mainly results from changes in the fuel mix in the power generation sector (see section 3.1.3), from assumptions regarding the iron and steel sector and from the projected development of international aviation. Consequently, 47% of the total GHG emissions in 2020 are anticipated to come from the ETS sector.

4. 20/20 target scenario

Next to the baseline, a selection of GHG and RES target scenarios is discussed. Two main target scenarios are being scrutinized and make up the subject of the present and following chapter: a scenario comprising a unilateral 20% EU GHG reduction and 20% EU RES development by 2020 and another for a multilateral 30% GHG reduction and 20% EU RES development by 2020, following the decision of the European Council to engage in a 30% GHG reduction if a comprehensive international climate change agreement can be reached. In this agreement, other developed countries commit themselves to comparable emission reductions and economically more advanced developing countries contribute adequately according to their responsibilities and respective capabilities. While studying these scenarios it is important to retain that they were constructed with a double target in mind: a greenhouse gas emission reduction objective coupled to a renewable development target. Both targets were taken up in the modelling. It is therefore not possible to isolate the impact one single objective can have on the energy or economic system. Readers interested in putting the focus exclusively on one of the targets are referred to other studies[26].

Other scenarios that were performed in the course of this one year study are concisely described and analysed in the part “sensitivity analyses”.

4.1. Description/rationale

First scenario to look into is the *20/20 target scenario*, short for the reduction scenario in which the 20% reduction in greenhouse gases by 2020 compared to 1990 levels is attained at European level and the 20% share of renewable energy in Gross Final Energy Demand by 2020 for the EU as a whole is reached, including a 10% share of renewable energy in transport in each Member State. At the Belgian level, the non-ETS, ETS and RES objectives in the *20/20 scenario* are as follows:

- First, in the non-ETS sector, it integrates the European Commission’s proposal for GHG reduction in the Belgian non-ETS by 15% in 2020 compared to 2005 emissions.
- Secondly, the effort performed in the Belgian ETS sector depends on the cap that is determined at EU level. The general allocation rule for the EU allowances to companies is auctioning. Nevertheless, companies belonging to sectors facing the risk of carbon leakage (leading to potential delocalisation) will receive free allowances. The assumption we made in this *20/20 target scenario* is that, over the 2013-2020 period, every year 55% of EU allowances will be auctioned while 45% will be freely allocated to companies.
- Thirdly, on renewable energy, the scenario includes the Belgian target proposed by the Commission, namely a 13% share of renewable energy in Gross Final Energy Demand.

26 See for example Federaal Planbureau (2006), *Het klimaatbeleid na 2012: Analyse van scenario’s voor emissiereductie tegen 2020 en 2050*.

The scenario also takes into account the various *flexibilities* allowed for in the European legislative proposals.

In the non-ETS sector, the Package foresees the annual use of CDM credits by each Member State up to maximum 3% of its 2005 emissions. Moreover, the ongoing discussions in the EU Council and Parliament make it clear that trade of annual emission allocations by States will also be allowed for. Accordingly, we made the assumption that such flexibility will lead to the equalisation of marginal abatement costs in the non-ETS sectors between the States and that 25% of the EU effort in 2020 will be realized via CDM[27].

In the ETS sectors, companies are allowed to trade EU allowances. They may also use CDM credits in the 2013-2020 period, although the amount of credits to be used in that period is limited to the amount of credits companies have been granted to use in the 2008-2012 (NAP II) period diminished by the amount of credits effectively used in the NAP II period. The following simplifying assumption is then put forward: companies will use the same amount of credits every year over the two periods, i.e. between 2008 and 2020. Therefore, the EU ETS will accomplish 25% of its reduction effort in 2020 via CDM.

As far as the RES target is concerned, discussions in the EU Council and Parliament currently foresee the possibility for any Member State to reach part of its objective in another Member State (so-called 'statistical exchanges' of renewable energy) or through the implementation of large projects in any country outside the EU27. Although there are still concerns as to whether the flexibility provided by the statistical exchanges will really work in practice, we make the assumption in this *20/20 target scenario* that RES flexibility does properly function. For convenience reasons, we will uniformly term it throughout the text as GO trade.

It must be stressed that the 'temporal flexibility' allowed for in the Proposals (namely 'carry-back' and 'carry-forward' in the non-ETS and banking in the ETS) cannot be analysed with the model used in this study.

The flexibility provided in the legislative proposals is such that marginal abatement costs in the non-ETS sector will be equalized across EU countries. Each year, marginal abatement costs will be equal to the carbon value. In the ETS sector, all EU companies will make use of flexibility (EU allowances and CDM credits) and equal their marginal abatement cost to the permits price that is represented by the ETS carbon value. Finally, assuming flexibility in RES ensures that the production of energy from RES will take place there where it is cheapest in the sense that the virtual subsidy to renewable energy production will be equalized across countries.

27 According to the Proposal, up to 30% of the effort in 2020 could be obtained through the use of CDM. Our choice of 25% reflects the fact that such flexibility might not be exhausted (to its maximum). Moreover, this may also reflect the existence of CDM transaction costs.

The corresponding carbon and renewable value[28] in the *20/20 target scenario* are given in Table 5 and compared to their level in the baseline.

Table 5: Carbon and renewable values for Belgium, baseline and 20/20 target scenario, year 2020

	Baseline	20/20 target scenario
Carbon value - ETS (€/tCO_2)	22	33.5
Carbon value - non-ETS (€/tCO_2)	0	25
Renewables value (€/MWh)	0	49.5

Source: NTUA

4.2. Impacts on the energy system

Following parameters will for the most part be analysed with respect to the baseline and up to the year 2020 (unless stated otherwise). This reasoning is followed to clearly demonstrate the effort society has to make in a given year to reach the set goals for 2020.

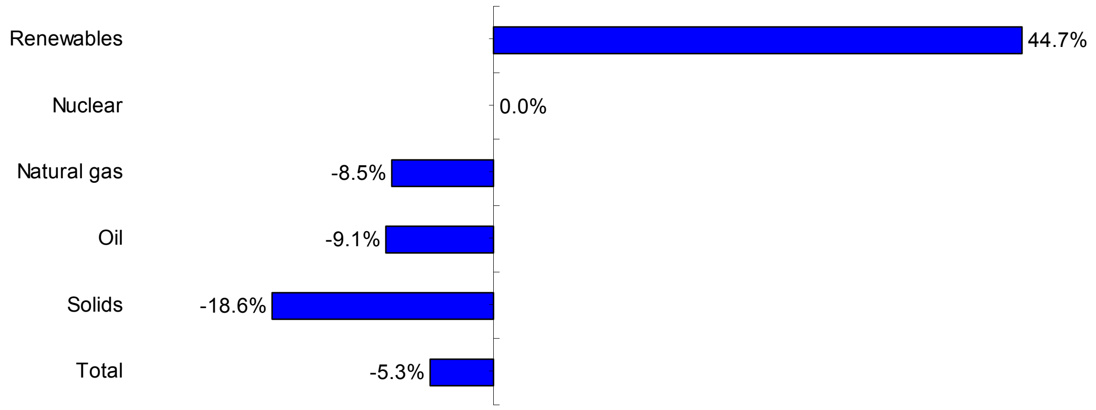
4.2.1. Gross Inland Consumption

When implementing the *20/20 target scenario*, the Gross Inland Consumption will be affected in two ways: energy demand will shrink and fuel switching will occur because of the installation of a carbon constraint and a RES target. Nevertheless the effect on energy demand prevails on the (rather limited) substitution effect. The following figure demonstrates the impact. In total, the GIC decreases by 5% in comparison to the baseline[29]. Hardest hit seems to be the consumption of solids that, through the installation of a CV, becomes a less attractive energy form for the production of electricity and heat. Oil and natural gas will also decline compared to the baseline, although the consumption of natural gas keeps on growing compared to the year 2005. A substantial development of renewables takes place (+45%), but they do depart from a rather small absolute amount (2022 ktoe or 4% of total GIC in 2005).

28 This renewable value corresponds to a share of 12.3% renewable energy in Final Energy Demand, the share Belgium would realize in a model run where the carbon values are 39.2 €/t CO_2 at EU-level for both ETS and non-ETS sectors and the EU renewables value amounts to 45€/MWh in order to achieve domestically the EU greenhouse gas reduction and renewable energy targets. The introduction of CDM flexibility, as foreseen in the proposal of the European Commission, reduces the EU carbon values, thus leading to higher EU final energy demand. Therefore, to reach the 20% EU RES target, the EU renewables value needs to be slightly higher than 45€/MWh. All EU Member States will be subject to the same changes and therefore the Steering Committee assumed that the Belgian RES share should not change significantly further to the introduction of CDM.

29 The 5% decrease is to be considered with respect to the baseline in that same year; compared to the starting position in 2005, the GIC still increases with 2%, mainly due to a growth in consumption of solids (+17%) and natural gas (+12%). The solids' consumption rise is to be put on the account of the iron and steel industry, whilst the increase in natural gas can be attributed to all sectors.

Figure 6: Gross Inland Consumption, 20/20 target scenario, year 2020: % change compared to the baseline



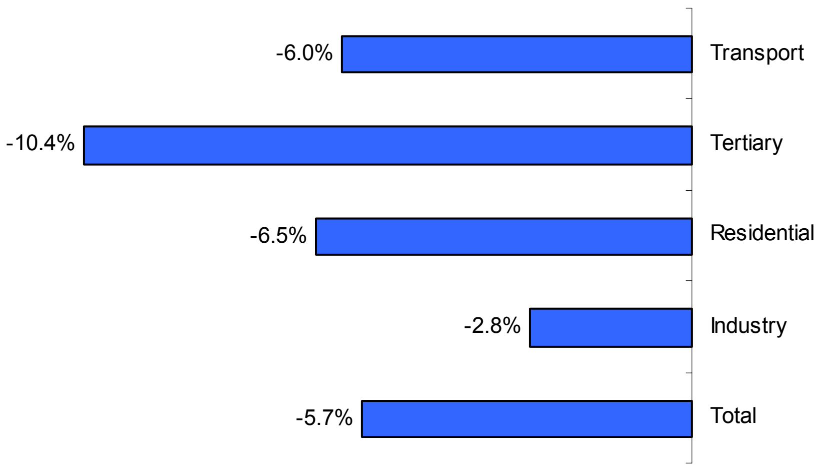
Source: PRIMES

We see that, when both targets are imposed, both total demand and imports of all fossil fuels (see Figure 13), including natural gas, decrease compared to the baseline. Interesting to note is that the imposition of the RES target (and matching RV) prevents gas demand from increasing as a substitute for coal in power and steam generation. This finding takes the edge off the possible adverse effects that climate change actions can have on gas import dependence and, hence, on security of supply issues.

4.2.2. Final Energy Demand

When focusing in on the final energy demand, we also see a decreasing trend: in 2020, 6% less energy is consumed by the final demand sectors compared to the baseline. Tertiary takes the largest cut, followed by households, industry takes the smallest.

Figure 7: Final energy demand, 20/20 target scenario, year 2020: % change compared to the baseline



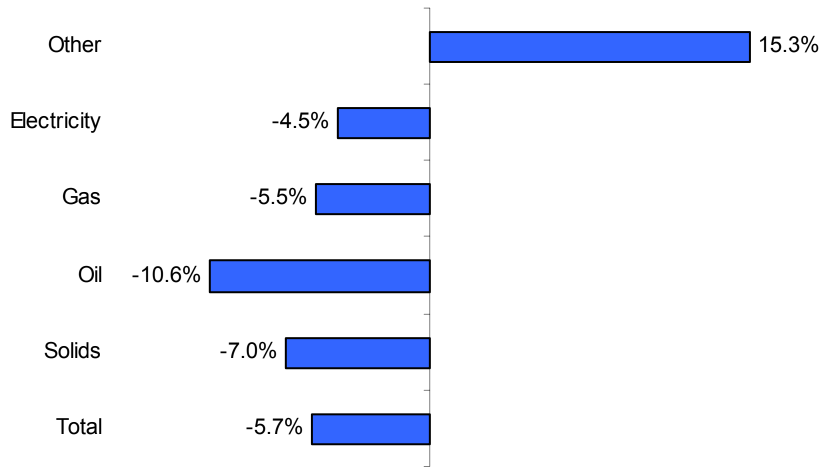
Source: PRIMES
NB: Transport does include aviation.

The fact that industry is comparatively less affected is caused by the Belgian industry being already relatively energy efficient (especially the energy intensive sectors). Next, only restricted possibilities for fuel switch exist within industry (due for a large part to certain industrial production processes needing one particular type of energy, e.g. petrochemicals). A last explanation is given by the decision taken by the Steering Committee to fix the evolution of the iron and steel industry (see also Annex 6.2): the level of production as well as the allocation between blast furnaces and electric arc furnaces is exogenously set to projection levels drawn up by the Flemish and Walloon Environment Administrations.

For the residential as well as for the tertiary sector, the most important option to reduce CO_2-emissions is the reduction of energy consumption by means of more efficient equipments and lower energy demand as fuel switching options are rather limited. For households, nonetheless, there appears to be a valid alternative to fossil fuels, being the installation of a heat pump. Heat pumps are able to substitute for fossil fuels in space heating systems by electricity-based technology. The scarcity of these options are due to a lack of co-generation in non-industrial sectors (e.g. district heating) and the fact that most fossil fuel switching options have already been largely exploited (coal or oil for heating purposes are already largely substituted by natural gas[30]). As a corollary, high disutility costs result (see part 4.4.1).

Looking at the consumption of the different energy forms in Figure 8, the above reasoning is confirmed. The only energy form that withstands the downward trend is renewable energy. Since its share still does not become significant, it is not able to turn the final demand decrease around (total FED decrease of 2400 ktoe against a gain from renewables of 600 ktoe compared to the baseline).

Figure 8: Final Energy Demand, 20/20 target scenario, year 2020: % change compared to the baseline



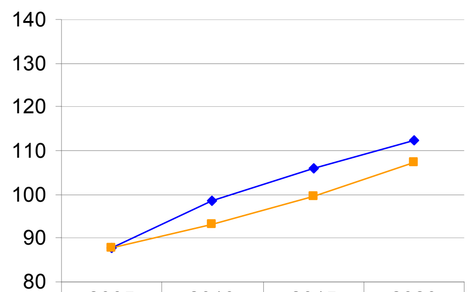
Source: PRIMES
NB: "Other" stands for renewable energy and heat.

30 In 2020, the share of natural gas in the residential sector is 37% and 38% in the tertiary sector.

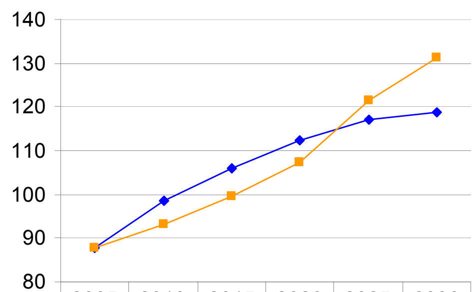
4.2.3. Power generation

Turning to power generation, we see that the GHG and renewables' objectives have an impact on the demand for electricity. When focusing on the period under investigation (2005-2020), one notices that the electricity demand in the reduction scenario is lower than in the baseline. This can be attributed to a first reaction of the system to the adoption of a carbon and renewable value, being a decrease in the general demand for energy services, hence electricity. This is mainly due to the fact that time constants in power generation are much longer than in mobile phones for example. Lifespans in power plants reach 20 to 40 years, meaning that only once every say 30 years, a capital turnover takes place. Therefore 2020 is rather short in time for the power sector to develop low cost carbon-free generation at a sufficiently large scale, whereas 2030 is not. When extrapolating over a longer time period (2005-2030), investments in even more efficient and/or carbon-low/carbon-free technologies become within reach. In Figure 9, we notice that, after 2020, the electricity demand recovers and crosses the baseline level between 2020 and 2025 to remain at a substantially higher level. In 2030, called-up electrical power[31] reaches 131 TWh (compared to 119 TWh in the baseline). This is then due to a second reaction of the system: a fuel switch from more expensive (rise in international energy prices and in CV) fossil energy forms to relatively cheaper ones (e.g. electricity), given time.

Figure 9: Called-up electrical power (TWh), baseline and 20/20 target scenario, evolution: period 2005-2020 and 2005-2030



	2005	2010	2015	2020
Baseline	88	99	106	112
20/20 target scenario	88	93	100	107



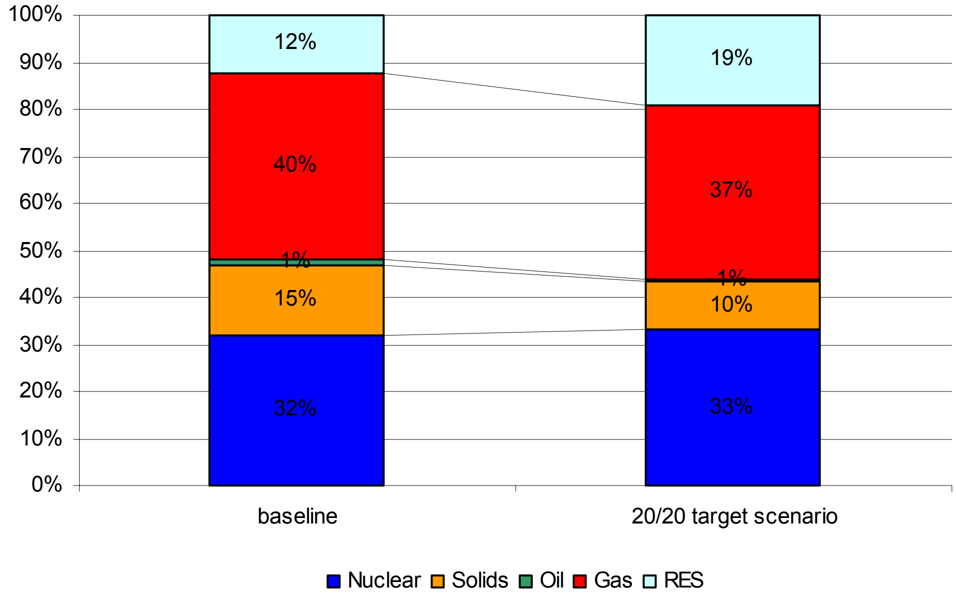
	2005	2010	2015	2020	2025	2030
Baseline	88	99	106	112	117	119
20/20 target scenario	88	93	100	107	121	131

Source: PRIMES, own calculations

To satisfy the demand, power generation must be sufficient. In the *20/20 target scenario*, net electricity generation in the year 2020 will be lower (102 TWh instead of 107 TWh in the baseline[32]) and basically consists of natural gas (37%), nuclear (33%) and renewables (19%). This last finding is represented in Figure 10, together with a comparative decomposition of the baseline.

31 This is the net electricity consumption plus the grid losses.
32 The difference between called-up electrical power and net electricity production can be attributed to net imports and transmission and distribution losses.

Figure 10: Net electricity generation (%), baseline and 20/20 target scenario, year 2020



Source: PRIMES

To resume the situation in the power sector, Table 6 shows a selection of sector specific parameters for both the baseline and the reduction scenario.

Table 6: Indicators related to the power generation sector, baseline and 20/20 target scenario, year 2005 and 2020

	2005	2020 baseline	2020 20/20 target scenario
Efficiency for net thermal electricity production (%)	31.9	45.2	45.4
Net imports ratio (%)	6.9	5.1	5.4
% net electricity from CHP	7.4	25.0	24.9
% electricity from RES	4.7	12.4	19.2
Share of non-fossil fuels in net power generation (%)	59.5	44.1	52.4
Net installed power capacity (GW)	15.3	20.8	21.0
Carbon intensity (tCO_2/GWh)	235	245	203
Electricity (final demand) per capita (kWh/capita)	7675	9569	9139

Source: PRIMES

The evolution of the average efficiency of thermal electricity production is closely related to the technology mix. The remarkable increase between 2005-2020 both in the baseline and the *20/20 target scenario* has to do with investments in combined cycle gas turbines (CCGT) that are characterized by high conversion efficiencies (close to 60% for new generation). The net imports ratio decreases somewhat over time because of lower net imports in both scenarios. Important to retain is that the level of net imports is exogenously fixed for all scenarios (and for all Member States).

The share of non fossil fuels in electricity production combines two elements: nuclear on the one hand, renewable energy sources on the other. The share of nuclear electricity decreases steadily in both scenarios further to the decommissioning of nuclear plants after an operating lifetime of 40 years. On the contrary, the share of renewable energy sources goes up: representing only 5% in 2005, it reaches 12% in 2020 in the baseline and 19% in the *20/20 target scenari*o. Similarly, the share of CHP (covering both fossil fuel as biomass based cogeneration) in electricity generation goes up steadily: from 7% in 2005, it reaches 25% in 2020 in both scenarios.

The installed power capacity increases by 36% over the period 2000-2020 in the baseline and slightly more in the reduction scenario (38%). This increase is required to meet the growth in electricity consumption in both scenarios. However, the power capacity increases at a higher pace than electricity demand. One reason is the slight drop in net electricity imports. Another is the decrease in the average utilisation rate of electrical capacities: in 2005, it was around 61%; in 2020, it is estimated to be 59% in the baseline and 55% in the *20/20 target scenario*[33].

Next, the subcategory of renewable energy sources in power generation is analysed in more detail. The table below depicts the net power generation and capacity for the reduction scenario in the year 2020, as well as the percentage of change compared to the baseline for that same year. Hydro and solar PV do not change with respect to the baseline, but wind and biomass and waste grow considerably. The wind accumulation can be ascribed to offshore wind: the reduction scenario foresees an extra 1000 MW installed capacity in 2020, what boils down to approximately 2000 MW installed offshore by 2020[34]. Biomass and waste make up the largest part of RES based electricity production (almost 11 TWh in 2020).

Table 7: Net power capacity (MW) and electricity generation (GWh), 20/20 target scenario, year 2020

	Net power capacity (MW)		Net electricity generation (GWh)	
	2020	% change compared to baseline	2020	% change compared to baseline
Hydro	108	0%	363	0%
Wind	3231	45%	8204	54%
Biomass and waste	2474	60%	10866	47%
Solar PV	93	0%	71	0%

Source: PRIMES, own calculations

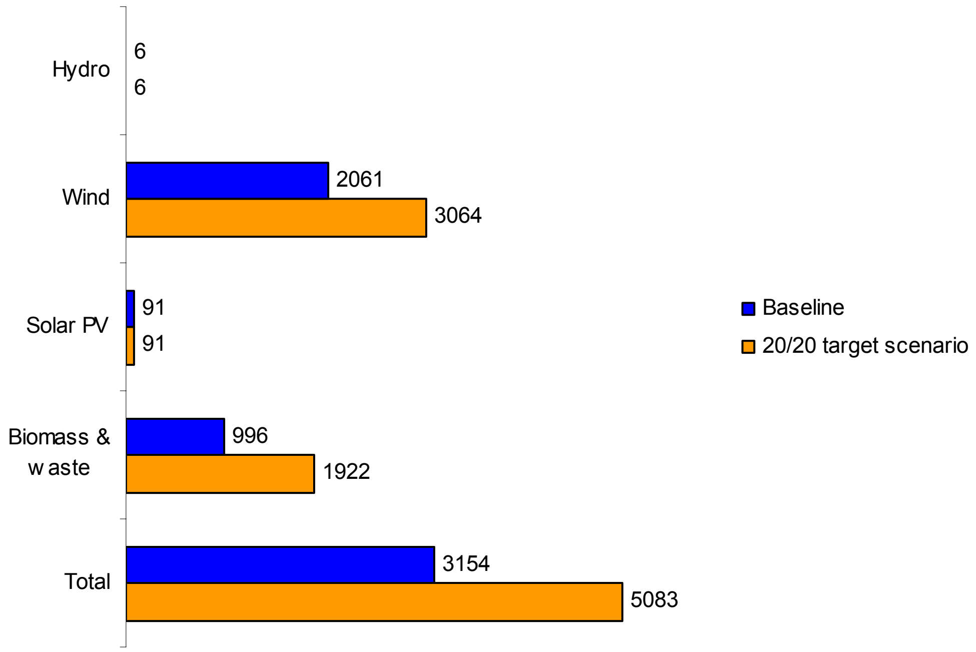
The graph below shows the progression from the year 2005 for the two scenarios discussed until now: the baseline and the *20/20 target scenario*. Hydro and solar do not take off spectacularly: the former because of a limited potential in Belgium, the latter because costs, even with a RV of 49.5 €/MWh, seem to be prohibitive. Wind and biomass and waste expand considerably in both scenarios, with an expected additional growth of both energy forms in the reduction scenario of

33 The decrease in average utilisation rate (i.e. generation/(installed capacity x 8760 hours)) is due to the higher share of power capacities based on intermittent energy sources such as wind and solar.

34 This is what is foreseen to be potentially built on the North Sea Continental Shelf (Ministerial Council in Oostende, March 21 and 22, 2004).

approximately 1000 MW on top of the baseline. In total, the reduction scenario banks on an extra 5000 MW installed starting from the 2005 level (+/-1000 MW).

Figure 11: Net installed RES power capacity (MW), baseline and 20/20 target scenario, year 2020: difference from 2005



Source: PRIMES

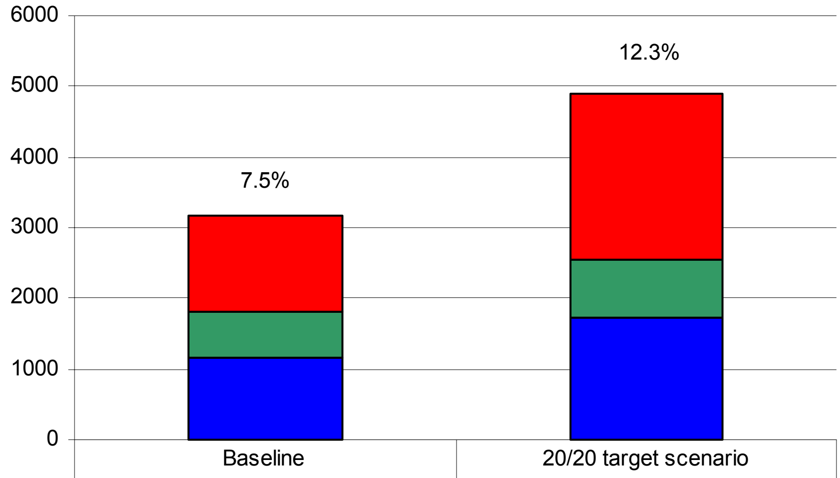
4.2.4. RES in Gross Final Energy Demand

After this thorough examination of "electric" renewables (RES-E), we assume a broader view and examine what share RES occupies in Final Energy Demand. As stated in part 3.1.4, a 13% share in Gross FED in Belgium should be reached by 2020 according to the January 2008 proposal of the European Commission. In the baseline, we saw that a 7.5% share or 3200 ktoe (36800 GWh) is obtained with current trends and policies. The *20/20 target scenario*, with the aid of the RV, steps up this effort and reaches 12.3%[35]. This boils down to an absolute amount of renewables in Gross FED of 4900 ktoe (57000 GWh). Figure 12 then splits up the different uses (heating and cooling[36], transport and electricity, or RES-H, RES-T and RES-E).

35 See also part 4.1 for a more elaborate explanation as to how the RV and the 12.3% in the *20/20 target scenario* are determined.

36 PRIMES categorises the electricity consumption (input) of heat pumps under "Final Energy Demand, Heating and cooling"; heat pumps therefore cannot be isolated from other electric heating and cooling uses. This might cause the percentage of RES-H to be slightly underestimated in the results shown.

Figure 12: Renewables in Gross Final Energy Demand (ktoe), baseline and 20/20 target scenario, year 2020



	Baseline	20/20 target scenario
RES-H	1360	2347
RES-T	640	827
RES-E	1167	1730

Source: PRIMES

NB: RES-H encompasses at the same time the heat produced in biomass-based CHP as the biomass' and solar heat used for space and water heating.

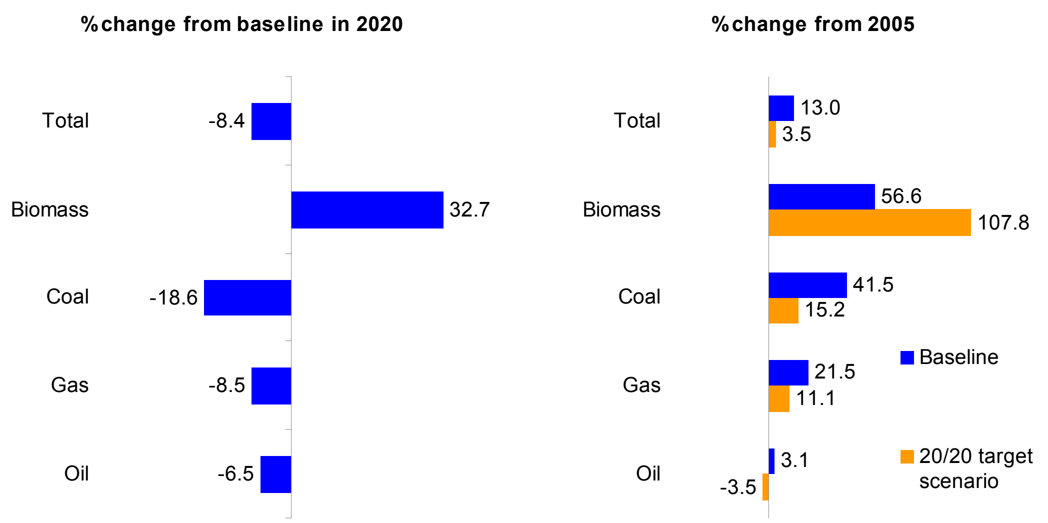
As shown in the figure, biofuels (RES-T) are part of the Package. Since the proposed RES Directive includes an objective for renewable energy in transport, the RES-T contribution is looked at in more detail. The absolute amount of biofuels in the target scenario rises to 827 ktoe or 9.5% of transport[37] (liquids demand), compared to 640 ktoe in the baseline (6.9%) and starting off from a level of 0 ktoe in 2005. In other words, this means that the incentive systems in place to reach the GHG and the RES target (methodologically simulated via the installation of the CV and RV) would normally suffice to reach the set goal of 10% renewable energy in transport for Belgium.

4.2.5. Import dependency

The GHG and RES targets contribute also to the achievement of a third objective: the security of energy supply. The substitution in favour of carbon free resources (i.e. RES) and the decrease in energy demand lead to reduced fossil fuel imports compared to the baseline. Total energy imports of Belgium go down by 8% compared to the baseline levels in 2020. Consequently, total energy imports are projected to be 3.5% above 2005 levels in 2020, compared to 13% in the baseline.

37 9.5% stands for the biofuels' contribution being produced domestically (in Belgium). The deficit (remaining 0.5%) can be purchased through a mechanism of intra-community trade, since the mandatory target of 10% renewable energy in transport on EU ground is honoured.

Figure 13: Changes in net energy imports for Belgium, 20/20 target scenario, year 2020



Source: PRIMES

The changes in the Belgian energy system, which characterize the *20/20 target scenario*, show that the effect on energy demand and development of RES prevail against substitution effects among fossil fuels. For instance, the imposition of a renewable value prevents the substitution from coal to natural gas in the power and heat sector and fosters instead the deployment of RES. As a result, imports of all fossil fuels decrease compared to the baseline. The extent of the decline depends, however, on the fossil fuel: -19% from baseline in 2020 for coal (the drop comes essentially from the power sector), -8.5% for natural gas (about two thirds of the decline comes from the power and heat sector and one third from energy efficiency gains), and -6.5% for oil (mainly in the transport sector). Furthermore, the results show that, in this scenario, the Belgian economy will need less oil in 2020 than in 2005. In monetary terms, the reduction in oil and gas imports translates into a saving of about 1.08 billion € in 2020 compared to the baseline (in € of 2005).

On the other hand, imports of biomass increase by 33% in 2020 compared to the baseline. This evolution results into a doubling of biomass imports in comparison with the situation in 2005. This result must however be put into perspective: the imports of biomass in the *20/20 target scenario* represent no more than 1.2% (0.6 Mtoe) of total (net) energy imports in 2020. In the current model based analysis, imports of biomass only relate to inputs for biofuel production. For all other types of biomass, imports are not modelled and supply comes exclusively from national production.

4.3. Impact on GHG emissions

The GHG emissions add up to 140.7 Mt of CO_2 equivalent in Belgium in 2020, 12% down from baseline emissions in 2020 (159.7 Mt). This emission level corresponds to a 0.5% reduction of GHG emissions from 2005 level, instead of an increase by 13% as projected under the baseline.

Table 8: GHG emissions in Belgium, 20/20 target scenario, year 2020

	2020 (Mt CO_2 eq.)	2020-change from baseline (%)	2020 vs. 2005 'domestic reduction' (%)	2020 vs. 2005 'proposed targets' (%)
All GHGs	140.7	-12.0	-0.5	-
All CO_2	118.0	-11.4	0.2	
ETS sectors	65.9	-11.4	11.7	-
ETS without aviation	60.5	-11.8	9.6	
Aviation	5.4	-6.5	42.1	
Non-ETS sectors	74.7	-12.4	-9.2	-15.0
Energy related CO_2	52.0	-11.4	-11.3	
Non-CO_2 GHGs	22.7	-14.7	-3.9	

Source: PRIMES, GAINS, NTUA

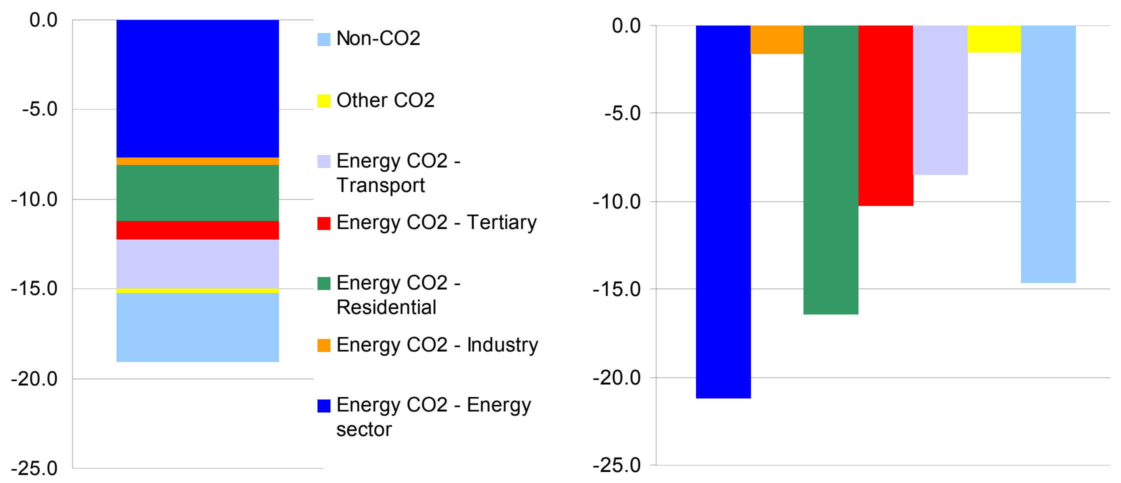
CO_2 emissions are projected to be close to the level of 2005 in 2020 (increase by 0.2%). However, this evolution corresponds to a decrease by 11% compared to the baseline emissions in 2020. In contrast, the emissions of non-CO_2 GHGs are projected to decrease by 4% in 2020 from 2005.

In the ETS sector, which experiences a carbon price of 33.5 €/tCO_2 in 2020, CO_2 emissions rise: 10% up from 2005 in 2020 without aviation, 12% if aviation is included in the ETS. Although the carbon price in the non-ETS sector is lower (25 €/tCO_2 in 2020), GHG emissions in this sector decrease in 2020 by 9% compared to the 2005 level. However, compared to baseline emissions in 2020, the GHG reduction effort in ETS and non-ETS sectors is similar, in the range of 11 to 12%. It is worth to underline that the emission trend in the ETS sector in Belgium is part of the European target of -21% in 2020 compared to 2005. The emission increase is due to more limited emission reduction possibilities in Belgium, at a carbon price of 33.5 €/tCO_2, compared to the situation in other Member countries (see infra and section 4.4.1).

Above projections only relate to emission reductions realized domestically. Access to CDM in the ETS and the non-ETS sectors allows Belgium to achieve further GHG emission reductions. In the Energy/Climate Package, national targets are only specified for the non-ETS sector. The ETS sector is dealt with at the European level. It is therefore not possible to calculate the total GHG emission reduction Belgium will be able to achieve in 2020 without making additional assumptions for the national ETS sectors. For instance, if one assumes an initial allocation of EU allowances based on the equalisation of marginal abatement costs across companies, then the total abatement effort of Belgium would be a 4.9% reduction of GHG emissions from the 2005 level. This percentage is only illustrative of what the total reduction effort of Belgium could be; it is not to be related to any concrete proposal or likely projection.

Figure 14 shows how the total domestic emission reduction effort is allocated among the sectors (as far as energy related CO_2 emissions are concerned) and among the different categories of GHG.

Figure 14: GHG emission reductions, 20/20 target scenario, year 2020: difference from baseline (Mt CO_2 eq. (left) and in % (right))



Source: PRIMES, GAINS, NTUA

NB: Transport includes international aviation; energy sector encompasses the power sector and other energy transformation sectors.

The major contributors to GHG emission reductions in Belgium, both in absolute and relative terms, are the energy sector, the residential sector and the non-CO_2 GHG. In the energy sector, the major part of the reduction takes place in the power sector; it results from fuel switching towards RES and to a lesser extent from a decrease in power production following a drop in electricity consumption. In the residential sector, a partial shift to RES and electricity (heat pumps for heating purposes) combined with large energy savings results also in significant CO_2 emission reductions. The reduction in non-CO_2 GHG emissions comes mainly from N_2O and more specifically from reduced fertilizer application in agriculture. In transport, industry and the tertiary sector, energy savings and energy efficiency improvement dominate the response of economic agents to the carbon price (and RES value). The changes in fuel mix have a comparatively smaller contribution to CO_2 emission reduction in these sectors.

4.4. Economic cost

The evaluation of the economic cost of the Energy/Climate Package for Belgium involves two complementary approaches. The first approach relies on the assessment of the direct cost (section 4.4.1) which encompasses two components: (a) the direct cost related to the domestic effort assessed with PRIMES and GAINS and (b) the cost related to flexibility and to distribution of auctioning rights in the ETS. The second approach deals with the macroeconomic impact of the Package and relies on the HERMES model (section 4.4.2).

4.4.1. Direct cost

a. Direct cost related to domestic reduction

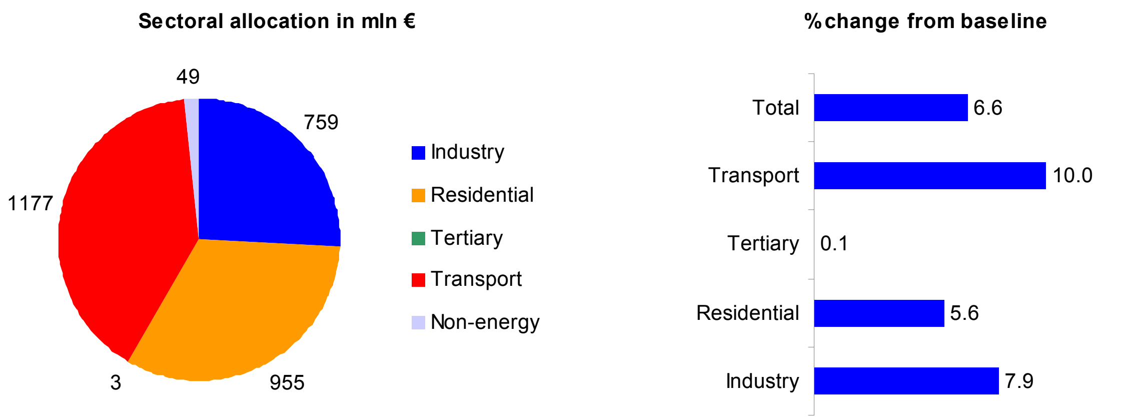
This section describes the cost of achieving the domestic GHG emission reductions and the domestic RES production assessed in the *20/20 target scenario*. This cost encompasses the additional costs, compared to the baseline, experienced in the Belgian energy system related to the domestic mitigation and renewable energy production efforts as a result of the carbon price and RES value (also referred to as energy related costs) and those resulting from mitigation measures for the non-CO_2 GHG. This cost excludes however the purchase of CDM credits and GO's as well as the costs related to the distribution of auctioning rights in the ETS. These costs are dealt with in the next section (section b).

The energy related costs include the annual payment of investments in RES and energy efficient technologies as well as stranded costs when e.g. energy equipments are prematurely replaced, the changes in operation and fuel costs and the costs of actions to remove barriers to energy efficiency improvement or to adapt energy consumption behaviour (the so-called disutility costs[38]).

The direct cost related to domestic effort does not represent a net loss to GDP. For example, the investments in new energy technologies will foster the economic activity in particular sectors and the use of economic instruments for meeting the GHG target can bring about additional public revenues that could be recycled into the economy. To account for these feedback effects on the Belgian economy, the macro-sectoral model HERMES was used. The results of the evaluation of the full macroeconomic cost of the *20/20 target scenario* are described in section 4.4.2.

38 More information about the rationale and modelling of disutility costs is provided in Capros (2008), pp. 27-28.

Figure 15: Direct cost related to domestic effort, 20/20 target scenario, year 2020



Source: PRIMES, NTUA

NB: The direct cost of domestic effort (i.e. additional cost compared to the baseline) amounts to 2.9 billion €. Costs are in € of 2005. Cost in transport only covers fuel costs.

Figure 15 shows the estimation of the direct cost related to the domestic effort for the year 2020 and how this cost is allocated among sectors. Cost figures reported under categories industry, residential, tertiary and transport refer to energy related costs while the cost under category non-energy relates to abatement measures for the non-CO_2 GHG and process related emissions of CO_2. The direct cost of domestic effort totals 2.9 billion € in 2020, 98% of which are energy related costs. This amount represents 0.72% of Belgium's projected GDP in 2020. The allocation of effort among sectors is the following: the transport sector takes the lead with 40%, followed by the residential sector (32%) and industry (26%), whereas the tertiary sector bears no additional cost compared to the baseline.

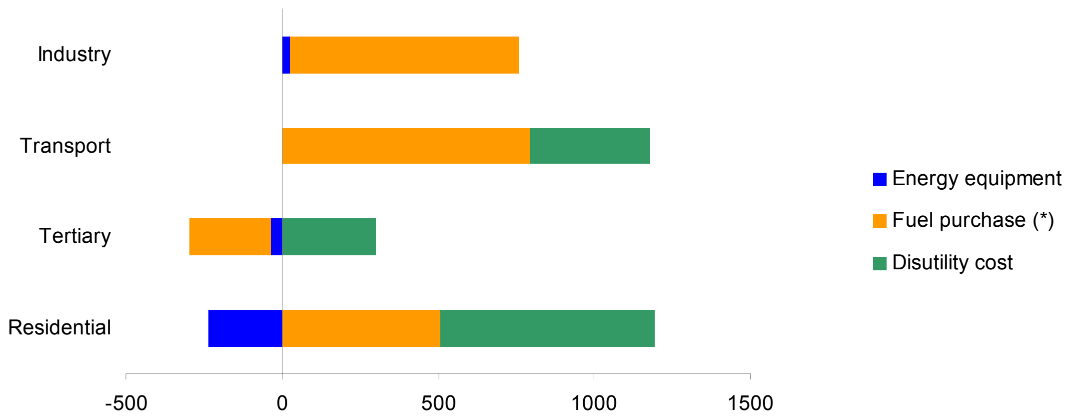
The domestic effort needed for meeting the emission reduction and RES deployment targets translates into an increase in energy related cost by 10% in transport, by about 8% in industry and by 5.6% in the residential sector compared to the baseline costs in 2020. These changes include the increase in costs in the power and heat sector[39]. Indeed, in the model based evaluation, increases in average power production cost are incorporated in the electricity prices paid by the final consumers, affecting the energy related cost of the final demand sectors.

As outlined at the beginning of this section, the direct cost related to domestic effort involves energy equipment costs, fuel purchase costs (where fuel encompasses also electricity and steam) and disutility costs. Figure 16 shows, for each final demand sector, how the additional cost is allocated among the three cost categories. The disutility costs represent about half of the additional cost; these costs are particularly high in the residential sector. The concept of disutility cost (or hidden cost) is explained in Capros et al., June 2008 Report, pp 27-28. In a nutshell, the

39 Large development of power generation from intermittent renewables entails additional costs for the reinforcement of power grids (and for new grid devices) and for backup power with flexible thermal units. These costs are accounted for in the PRIMES model and are included in the compliance costs.

disutility cost reflects the evidence from statistics that consumers do not act as expected by engineering-oriented analysis which points to energy savings with zero or even negative costs, the so-called no-regret energy saving potential. This observed behaviour is explained by factors such as lack of information, market barriers, less comfort, etc. The disutility cost is only relevant for the residential, tertiary and transport sectors. For industry, changes in energy consumption patterns and equipments are assumed to result from calculation of return on investments, etc.

Figure 16: Direct cost related to domestic effort, per sector and category, 20/20 target scenario, year 2020 (in mln € of 2005)



Source: PRIMES, NTUA

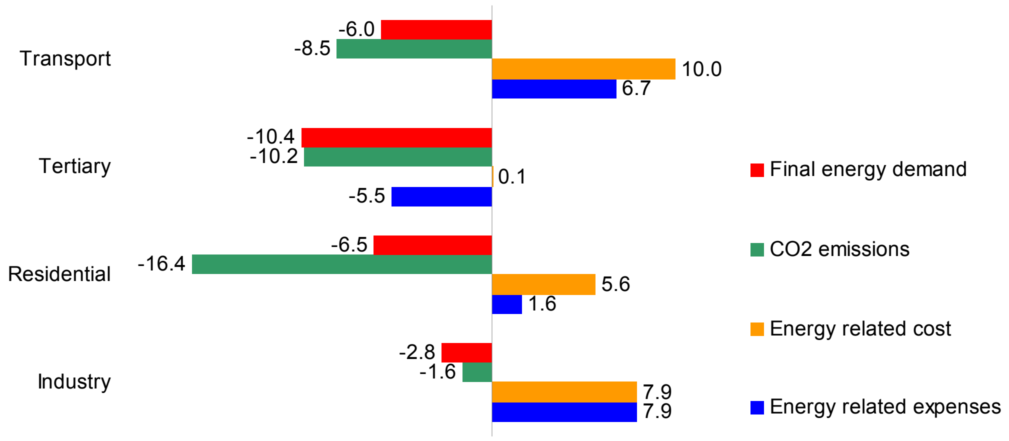
(*) Fuel purchase costs relate to all energy sources (fossil, electricity, steam, RES).

For industry, the additional cost comes mainly from the purchase of energy commodities, of which 60% relate to electricity and steam. In transport, the evaluation only involves fuel purchase and disutility costs: the former represents two thirds of the additional cost and the latter the remaining third. There is no additional cost in the tertiary sector because the disutility costs are fully counterbalanced by the decrease in equipment and fuel costs. Finally, the additional cost in the residential sector is dominated by the disutility cost and to a lesser extent by the increase in fuel purchase costs. The latter increase is due, for the most part, to the rise in electricity prices. In the residential and tertiary sectors, the decrease in equipment cost results from a drop in the demand for energy services.

The model-based evaluation of costs is so that changes in electricity prices are related to changes in average electricity production costs. In the *20/20 target scenario*, the power sector faces higher carbon prices than in the baseline and is also influenced by the RES value. As a result, power generation costs increase compared to the baseline. The rise is estimated to be about 15% in 2020.

The following figure goes a bit further in the analysis. It puts into perspective the relationship between costs and decreases in CO_2 emissions and energy consumption. The difference between energy related *cost* and energy related *expenses* is the disutility cost. Although the disutility cost is a real cost supported by the economic agents or the economy as a whole, it is not, strictly speaking, a spending of the energy consumers. Energy related expenses therefore only encompass equipment and fuel costs.

Figure 17: Sectoral indicators, 20/20 target scenario, year 2020: % change compared to the baseline



Source: PRIMES, NTUA

The figure shows that the additional cost incurred by industry (+7.9%) is high in comparison with the relatively low decrease in energy demand (-2.8%) and in CO_2 emissions (-1.6%). This result reflects the rather low fuel substitution possibilities and the quite high level of energy efficiency of the sector. These are results for industry as a whole. The impact of the *20/20 target scenario* on costs, CO_2 emissions and energy consumption varies according to the industrial sector and in particular between the energy intensive sectors and the others. For instance, the increase in energy related cost is comparatively lower in energy intensive sectors (in the range between +5 and +9%) than in the non intensive ones (in the range between +8 and +14%). The figures for each industrial sub-sector are provided in annex 6.5.3 as well as the translation of energy cost increases into increases of the unit cost of production.

On the opposite side, the rise in energy expenses is relatively low in the residential sector (+1.6%) and even negative in the tertiary sector (-5.5%) compared to the impact on energy consumption (-6.5% and -10.4% respectively) and CO_2 emissions (-16.4% and -10.2% respectively). In the residential sector, the remarkable drop in CO_2 emissions comes mainly from fuel substitution, namely the development of RES and electric heat pumps replacing partly gas and oil boilers for space heating. Energy savings play also a non negligible role as Belgium is one of the European countries with the highest energy consumption per household. All in all, energy related expenses per household are estimated to be 50 € up from the baseline in 2020 (in € of 2005). In the tertiary sector, an important energy saving potential is identified whereas fuel substitution possibilities are projected to be small. The shrink in energy related expenses compared to the baseline results from the fact that higher expenses in purchasing more efficient energy equipment are more than counterbalanced by savings in fuel costs (electricity included). Finally, the heavy reliance of transport on petroleum products limits fuel switching to the biofuels option, as part of the EU Energy/Climate Package. The response of transport to the carbon price goes also through vehicle efficiency improvement and activity reduction.

More detailed figures of the energy related cost in industry and in tertiary and residential sectors are provided in annex 6.5.2.

b. Total direct cost

The total direct cost is the sum of the direct cost related to domestic effort (see section a above) and costs related to flexibility. The latter involve the purchase of CDM and AAU credits in non-ETS, the purchase of GO's and costs related to the distribution of auctioning revenues[40]. Table 9 shows the estimation of the direct cost including flexibility of the *20/20 target scenario* in 2020, i.e. the additional cost compared to the baseline.

Table 9: Total direct cost, 20/20 target scenario, year 2020

	In % of GDP	In million € of 2005
Cost related to domestic effort	0.72	2900
Purchase of CDM and AAU credits in non-ETS	0.03	120
Purchase of GO's	0.04	160
Distribution of auctioning rights in ETS	0.08	340
Total direct cost	0.86	3520

Source: PRIMES, NTUA, own calculations

The *20/20 target scenario* assumes that 25% of the GHG reduction effort at EU27 level in the non-ETS sector can be realized by means of CDM. For Belgium, this statement translates into the following allocation of the 15% GHG reduction target in the non-ETS sector: emissions are reduced domestically by 9.2% in 2020 from 2005 levels; the remaining 5.8% is realized by means of purchase of CDM-credits and/or trade in emission allocations. Assuming that the CDM price is the same as the carbon price for the non-ETS sector (i.e. 25 €/tCO_2), the purchase of CDM credits is estimated to be 120 million € which is equivalent to 0.03% of the GDP in 2020.

Similarly, the purchase of GO's is estimated on the basis of the difference between the proposed target of 13% for Belgium and the domestic RES share of 12.3% imposed in the *20/20 target scenario* and a GO price equal to the RES value in 2020 (i.e. 49.5 €/MWh). This computation leads to a figure of 160 million € which is equivalent to 0.04% of the GDP in 2020.

40 In the model it is assumed that Belgian auctioning revenues correspond to the amount paid by Belgian industries to purchase their emission allowances (at auctions organized by EU Member States or in the market). However, according to the Commission proposal, auctioning rights for the ETS will be distributed among the Member States on the basis of the share of their 2005 ETS emissions in the total EU 2005 ETS emissions. The value of this share is lower than the amount paid by Belgian industries to cover their emissions. This difference is a net cost for Belgium that must therefore be taken into account.

Finally the cost associated to the distribution of auctioning rights in ETS is estimated to represent 340 million € or 0.08% of Belgium's GDP in 2020.

The total direct cost of the *20/20 target scenario* is projected to amount to about 3.5 billion € in 2020, i.e. 0.86% of the GDP. This is high compared to the direct cost of other EU15 countries as calculated in the Impact Assessment of the European Commission. The energy and emission trends in the baseline as outlined in Chapter 3 are certainly part of the explanation. Other explanatory factors include, amongst others: a large share of energy costs as percentage of GDP; high energy consumption per household and limited fuel switching possibilities in the tertiary and residential sectors (high share of natural gas) and thus high disutility costs; limited fuel switching possibilities in the power sector due to nuclear phase-out, limited development of RES production and district heating and high share of natural gas; exogenously fixed imports of electricity; limited possibilities for fuel switching in industry (inherent to certain production processes); relatively energy efficient industry (especially energy intensive sectors) and cost related to distribution of auctioning rights in ETS. However, a more in depth study including the national circumstances in other EU15 Member States is required to fully explain this difference.

4.4.2. Macroeconomic impact

As stressed in the previous sections, the direct cost does not account for the feedback effects on the Belgian economy and its sectors. From a macroeconomic perspective, it is needed to take into account the changes in agents' behaviour and demand level resulting from the rise in costs and in prices implied by the higher energy prices. Also, the investments in energy efficient equipment and in new technologies are not just costs for households and firms, they generate revenues for the sectors (building, manufacturing…) which produce these equipments. Furthermore, the additional public revenues generated by e.g. the auctioning of emission allowances can have strong impacts on the cost of labour or on investments, depending on the way these revenues are used. To account for these feedback effects, the macro-sectoral model HERMES was used.

Several links are required between the PRIMES-based analysis and the HERMES model to make the analysis consistent.

First, the carbon values resulting from PRIMES for the ETS and non-ETS sectors are introduced in HERMES. For the ETS sector the interpretation is straightforward, the carbon value is the equilibrium price of carbon permits on the EU market. For the non-ETS sectors this carbon value is interpreted in HERMES as a hypothetical CO_2-tax, as a proxy for the simulation of emission reduction policies. This means on the one hand that energy for heating of houses and buildings, or for transport, becomes more expensive (depending on the carbon content of the fuel) and on the other hand it means that the government receives the revenues of this hypothetical CO_2-tax in the non-ETS sector.

Secondly, future electricity prices and the evolution of the structure of electricity production are PRIMES' outputs which are used by HERMES to perform policy simulations. The RES target is thus taken into account to the extent that it has an impact on the electricity sector and on the carbon values.

Thirdly, the amounts paid related to the flexibility allowed (CDM, GO, AAU) are introduced in HERMES.

Before presenting the macroeconomic impact, it is worth describing the *ex ante*[41] *effects* of the *20/20 target scenario*, namely the impact on energy prices, the *increase in public receipts* and the *modification of the international context*.

The following table presents the *ex ante impacts* of the introduction of the carbon values on the main energy prices. It refers to (all taxes included) prices paid by the final consumer and calculated by the energy module of HERMES, except electricity prices which are provided by PRIMES[42]. As can be seen, the impact depends on the carbon content of the product, but also on the initial price of the energy product (which depends, partly, on the taxation policy of the public authorities). The impact is high for solid fuels (which have a high carbon content) and relatively low for gasoline and diesel oil. All in all, the average energy price would be increased by a bit less than 13% in 2020 above baseline levels. For households, the increase would be limited to 10%.

Table 10: Impacts of carbon values on energy prices, 20/20 target scenario (% change compared to the baseline)

	2010	2015	2020
Solid fuels			
(a) Households and services	17.2	18.8	21.1
(b) Industry	57.9	79.7	100.7
Liquid fuels			
(a) Gasoline	4.1	5.1	6.0
(b) Diesel oil	6.0	7.1	8.1
(c) Fuel for heating	11.2	13.4	15.3
Natural gas			
(a) Industry	9.9	13.4	17.0
(b) Households	8.4	9.8	11.3
Electricity[43]			
(a) High tension	9.1	14.9	17.5
(b) Low tension	4.4	7.4	12.3
Average energy price	7.6	10.3	12.7
Of which households	6.3	7.9	10.0

Source: PRIMES, HERMES

41 "Ex ante" means before simulation of the impacts of the recycling options.

42 The modelling, and hence forecasting, of electricity prices is a difficult task due to the non competitive structure of this sector and to the existence of important fixed costs. Actually, electricity prices used here are based on the average costs of production.

43 The changes in electricity prices are calculated with the model PRIMES in which the pricing of electricity follows the Ramsey-Boiteux principle, which is close to average cost pricing. The principle is interpreted as a regime of regulated monopoly for new technologies, but also as a result of long-run equilibrium of monopolistic competition in case of mature technologies. The selling price of electricity that each consumer faces is then derived by adding transport and distribution costs, mark-ups and taxes. This price setting mechanism may lead to electricity prices that are considerably different from current market prices.

The *20/20 target scenario* implies a non negligible *increase in public receipts*, coming from the introduction of a carbon value (e.g. CO_2 tax) for the non-ETS sector and from the auctioning rights paid by the ETS sector (each year, an average share of 55% of the total cap is supposed to be subjected to auctioning, based on information available in the European Commission proposal). As shown in Table 11, the potential public revenues amount to about 4.1 billion € (or 0.75% of GDP) in 2020. 900 millions are estimated to come from the auctioning of emission rights in the ETS sector, the remaining 3.16 billion resulting from the taxation in the non-ETS sector. It is worth noticing that the amount of these new public receipts shown in the table used for recycling depends on the amount used for the purchase of flexible mechanisms (CDM and GO).

Table 11: New public receipts, 20/20 target scenario (in bn €-current prices)

	2010	2015	2020
(1) Industry	0.00	0.64	0.90
(2) Services	0.59	0.91	1.32
(3) Households (lighting, heating)	0.52	0.73	0.99
(4) Transport	0.52	0.67	0.85
(a) Households	0.20	0.27	0.33
(b) Firms	0.32	0.40	0.52
Total	1.63	2.95	4.06
In % of GDP	0.44	0.65	0.75

Source: HERMES

An important aspect of the simulations concerns the *modification of the international environment*. Indeed, the Energy/Climate Package has an effect on the EU economy as a whole and, thus, on our trading partners. In this context, the European macro-econometric model NEMESIS was used to compute the effects of the Package on the different economies and, thus, the effects on the Belgian export market and on the import and export prices. The impacts are given in Table 12, both for the no recycling simulation (left part) and for the simulation where all public revenues are recycled in reductions of social contributions paid by employers (right part). It appears that, in case of public receipts recycling, impacts are less important, especially regarding international prices.

Table 12: Impact on potential export market and on import and export prices, 20/20 target scenario (% change compared to the baseline)

	No recycling of public receipts			Full recycling of public receipts		
	2010	2015	2020	2010	2015	2020
Potential export market	-0.02	-0.21	-0.48	-0.04	-0.18	-0.30
International import prices	0.03	0.29	0.35	-0.02	0.12	0.07
International export prices	0.04	0.39	0.48	-0.02	0.09	0.04

Source: NEMESIS

The macroeconomic impact of the *20/20 target scenario* is now presented according to two recycling modes: no recycling of new public receipts, on the one hand (section a), and full recycling of new public receipts in reductions of social contribution paid by employers, on the other hand (section b). The results of these two recycling options indicate a possible range of the impacts on the Belgian economy; the actual impacts could lie in between. The results of the other recycling options are given in Annex 6.6.1.

a. No recycling of new public receipts

In this simulation, the auctioning and tax revenues collected in the three energy demand sectors (firms, households and transport) are not invested in the economy but come as a net addition to the public finances. This simulation can be regarded as the most pessimistic scenario for the economy, and is named the *no recycling policy*.

Table 14 (left part) presents the results of the variant simulated by HERMES. Results are given for 2010, 2015 and 2020. Unless stated otherwise, figures refer to the percentage change between the results of the *20/20 target scenario* and the baseline results for that year.

The increase in energy prices has negative effects on the economic activity, which is also affected by the expected decrease in potential markets. As new public revenues are not recycled, they cannot mitigate this economic downturn. In 2010, GDP is 0.07% lower than its baseline level and in 2020 the total loss in GDP reaches -0.45%, which means an average loss of 0.041% by year. Both domestic demand and exports are affected by the policy shock of the variant. Investment is the most depressed demand component, particularly firm investment (-1.69% in 2020) mainly as the result of the fall in production. The contraction of real household disposable income and the rise in consumption prices (larger than the health index rise) bring household consumption down, losing 0.98% in 2020.

Exports are also affected by the no recycling policy, though to a lesser extent than domestic demand variables (-0.57% in 2020). Foreign trade is handicapped by the less attractive international perspectives the variant involves, and by the rising of export prices due to higher production costs (higher energy prices) and higher international prices. At the same time, imports get heavily eroded by 0.80%, as the joint consequence of the decrease of energy demand (-3.11%) and the fall in domestic demand (driving less import demand for goods and services). Notice that the speed of inflation generated by the rise in energy prices slows down after 2015 (only +0.11% between 2015 and 2020).

Simulation results further indicate that the *20/20 target scenario* without recycling leads to a drop in employment. Around 16,450 cumulated jobs could be lost in 2020 as the direct result of firms' costs' increase and the slowdown of economic activity. This cut would represent 0.35% of job reduction with respect to the baseline. As value added is more affected by the policy shock than employment, productivity per head (slightly) lowers in 2020. Inversely, unit labour costs would increase (+0.90% in 2020) because total wages would go up (caused by inflation) and output decreases. Besides, the share of gross operating surplus in the value added lowers by 1.06% in 2020 (wage share rises).

At sectoral level, the impact of the no recycling policy on production and employment is heterogeneous. Production in energy faces the highest fall, evaluated at -3.17% in 2020. In manufacturing industry, production is reduced by 0.74% with respect to the baseline, a fall especially observed in the sectors of intermediary and consumption goods. For construction, the loss percentage amounts to 0.88% in 2020. On the services side, credit and insurances suffer much (-1.35%) while the effects on health sector are quite limited (-0.09%). Production in the primary sector is cut by 1.6% as the result of the high sensitivity of this sector to (downwards) international demand.

Job reductions in percent spread differently among sectors. The most affected sector in 2020 is construction (-1.01%), followed by energy (-0.78%) and other market services (-0.67%). In manufacturing industry, the impact of the no recycling policy is less pronounced (-0.28%). Again, health sector records the lowest impact (-0.09%).

b. Full recycling of new public receipts in reductions of social contributions paid by employers

In this second simulation, both the auctioning revenues and the carbon value receipts are recycled in the economy through a reduction of social contributions paid by employers. This simulation defines the most optimistic scenario for the economy and should be viewed as a strong green fiscal reform.

Table 13 gives the impact of this recycling policy on the social contributions paid by the different sectors. So it reports the new public receipts of Table 11 diminished by the purchase of flexibility mechanisms allowed in the *20/20 target scenario*. Notice that the reduction was applied linearly to legal social security contributions rate paid by employers. In 2020, it turns out that the total reduction would attain more or less 7% of total contributions i.e. 3.78 billion €.

Table 13: Reduction in social contributions paid by employers, 20/20 target scenario, full recycling policy

	In million €-current prices			In %		
	2010	2015	2020	2010	2015	2020
Energy	-31	-51	-65	-2.64	-3.70	-3.92
Intermediary goods	-155	-245	-302	-4.30	-5.99	-6.33
Equipment goods	-101	-157	-188	-4.73	-6.56	-6.92
Consumption goods	-124	-191	-226	-4.95	-6.85	-7.20
Construction	-115	-197	-257	-5.15	-7.19	-7.67
Transports and communication	-162	-276	-367	-4.46	-6.29	-6.66
Trade, hotels, restaurants, ...	-284	-500	-663	-4.83	-6.81	-7.26
Credit and insurances	-144	-183	-230	-4.47	-6.22	-6.60
Health care	-219	-415	-594	-5.32	-7.50	-8.09
Other market services to households and services	-328	-620	-887	-4.83	-6.76	-7.23
Total	-1632	-2834	-3779	-4.68	-6.57	-7.02

Source: HERMES

Next, we discuss the simulation results of the selected policy, the figures of which are shown in Table 14 (right part).

Under the full recycling assumption, the impact on GDP of the increase in energy products prices is quite limited and only reaches -0.07% with respect to the baseline in 2020. This corresponds to an average annual loss of 0.006%. Nevertheless, the effects on households and firms are not identical.

Household consumption generally benefits from the full recycling of public revenues. Indeed, the impact of the variant is slightly positive in 2010 and 2015 (+0.03% and +0.05%, respectively). Actually, over this period, the fall in real disposable income is more than compensated by the decrease in unemployment. At the end of the simulation period, the impact is however slightly negative (-0.03%) as inflation speeds up. On the firm side, investment decreases less than in the no recycling case. The reduction of social contributions paid by employers lowers the production costs but this reduction does not compensate entirely the increase of energy costs in the consumption prices. Furthermore, as production and exports both fall, the overall impact on investment remains negative.

With the *full recycling* of public revenues, Belgian trade with other countries is less depressed than under the no recycling assumption. In 2020, exports are cut by 0.46% with respect to the baseline while imports decrease by 0.53%. The impact on imports of the full recycling tax policy is less pronounced than in the no recycling case because domestic demand is less affected. At the same time, exports remain negatively affected by the decrease in potential markets and the rise in international prices (but less than in the first simulation). Thus, the current external balance increases less than in the no recycling policy. Finally, the *full recycling policy* generates less inflation (+0.63% in 2020 for the deflator of private consumption, +0.50% for the health index).

The increase in employment is the main positive achievement of the full recycling policy. Around 25,290 cumulated jobs are created in 2020 on account of the reductions in employers' social security contributions, meaning a gain in employment of +0.55%. Also, more new jobs are generated in the period 2010-2015 (+12,170) than in the period 2015-2020 (+7,800), as economic growth starts deteriorating with respect to the baseline in 2015 (the negative impacts of the policy on the economy speed up then). Productivity per head is severely decreasing with the upwards move of employment. Unit labour costs now decrease with regard to the baseline (they were increasing with the no recycling of tax revenues) as firms' value added is not much affected by the recycling policy (the cut in production equals the cut in intermediary consumption) while total wages fall in the firm sector. Actually, employment is stimulated by the reduction in the wage costs per head resulting from the reduction policy in employers' social security contributions.

The implementation of the *20/20 target scenario* with full recycling has a negative effect on total production in most sectors. However, the impacts are lower than the ones observed under the no recycling assumption of public revenues. The fall in production is the highest for energy (-2.76% in 2020) while agriculture lowers by 0.77% and credit and insurances by 0.42%. The remaining sectors are quite moderately affected so that the recycling policy under analysis largely contributes to attenuate the negative impact of energy prices' increases on these sectors. Besides, in transports and communication, as well as for equipment goods, the effect of the full recycling policy is positive over the simulation period (around +0.07% in 2020). In the health sector, the final impact on production is checked to be similar whether the recycling is implemented or not.

Finally, most sectors benefit from the full recycling policy in terms of employment. The positive effects are important in equipment goods, consumption goods and other market services (experiencing an increase by more than 1% with respect to the baseline). For trade, credit and insurances, as well as health, the gains are less pronounced though appreciable (between +0.19% and +0.33%). Nevertheless, in two sectors, employment is cut down by the full recycling policy: energy (unsurprisingly, losing 0.40%) and agriculture (though insignificantly).

Table 14: Macroeconomic results, 20/20 target scenario, no recycling policy vs. full recycling policy

% change from baseline	No recycling of public receipts			Full recycling of public receipts		
	2010	2015	2020	2010	2015	2020
MAIN MACROECONOMIC RESULTS						
Total production	-0.15	-0.54	-0.80	-0.04	-0.13	-0.27
Energy (Final expenditures, in 2000 prices)	-0.91	-2.01	-3.11	-0.89	-1.89	-2.87
Demand components (volumes)						
Households consumption	-0.10	-0.50	-0.98	0.03	0.05	-0.03
Investments	-0.15	-0.85	-1.26	-0.13	-0.59	-0.60
of which Firms	-0.21	-1.21	-1.69	-0.18	-0.95	-1.01
Total domestic demand	-0.10	-0.47	-0.82	-0.02	-0.11	-0.16
Exports of goods and services	-0.10	-0.32	-0.57	-0.08	-0.23	-0.46
Imports of goods and services	-0.12	-0.44	-0.80	-0.12	-0.31	-0.53
GDP	-0.07	-0.31	-0.45	0.02	-0.01	-0.07
Deflator of private consumption	0.56	0.91	1.02	0.44	0.48	0.63
Health index	0.45	0.80	0.91	0.33	0.35	0.50
Total employment						
. in thousands	-1.29	-8.00	-16.45	5.32	17.49	25.29
. in %	-0.03	-0.18	-0.35	0.12	0.38	0.55
Productivity per head (market branches)	-0.04	-0.13	-0.07	-0.12	-0.47	-0.73
Unit labour cost (Market branches)	0.39	0.86	0.90	-0.79	-0.86	-0.64
Real disposable income	-0.39	-0.75	-1.20	-0.28	-0.23	-0.30
Gross operating surplus of firms (ratio)	-0.18	-0.78	-1.06	0.61	0.20	-0.02
MAIN SECTORAL RESULTS						
PRODUCTION (volumes)						
Agriculture	-0.31	-1.25	-1.6	-0.07	-0.51	-0.77
Energy	-0.81	-2.15	-3.17	-0.77	-1.90	-2.76
Manufacturing industries	-0.19	-0.66	-0.74	0.00	-0.07	-0.11
. Intermediary goods	-0.24	-0.80	-0.88	-0.05	-0.20	-0.23
. Equipment goods	-0.12	-0.41	-0.37	0.03	0.03	0.06
. Consumption goods	-0.19	-0.69	-0.86	0.03	-0.01	-0.10
Construction	-0.11	-0.52	-0.88	-0.06	-0.15	-0.17
Transports and communication	0.00	-0.26	-0.48	0.12	0.15	0.08
. Transport by rail	0.02	-0.15	-0.30	0.08	0.08	0.03
. Road transport	-0.13	-0.52	-0.80	-0.01	-0.11	-0.28
. Water and air transport	-0.15	-0.65	-1.10	-0.01	-0.16	-0.45
. Other transports and communication	0.07	-0.12	-0.30	0.18	0.29	0.28
Trade, hotels, restaurants, ...	-0.04	-0.34	-0.62	0.08	0.10	-0.03
Credit, insurances	-0.22	-0.67	-1.35	-0.07	-0.03	-0.42
Health	0.00	-0.04	-0.09	0.01	0.00	-0.08
Other market services	-0.07	-0.38	-0.65	0.01	0.00	-0.10
Total market branches	-0.15	-0.56	-0.83	-0.03	-0.12	-0.25
EMPLOYMENT						
Agriculture	0.00	-0.06	-0.16	0.01	0.01	-0.02
Energy	-0.22	-0.42	-0.78	-0.20	-0.21	-0.40
Manufacturing industries	-0.01	-0.09	-0.28	0.04	0.51	0.78
. Intermediary goods	-0.01	-0.15	-0.40	0.01	0.10	0.05
. Equipment goods	-0.03	-0.11	-0.09	0.04	0.53	1.21
. Consumption goods	0.00	-0.02	-0.27	0.07	0.84	1.20
Construction	-0.12	-0.58	-1.01	0.45	0.56	0.60

% change from baseline	No recycling of public receipts			Full recycling of public receipts		
	2010	2015	2020	2010	2015	2020
Transports and communication	0.03	-0.05	-0.16	0.24	0.57	0.65
. Transport by rail	-0.05	-0.33	-0.55	0.22	0.63	0.75
. Road transport	0.11	0.06	-0.06	0.41	0.93	1.06
. Water and air transport	0.04	-0.15	-0.47	0.28	0.77	1.18
. Other transports and communication	0.01	-0.04	-0.10	0.16	0.35	0.38
Trade, hotels, restaurants, ...	-0.01	-0.19	-0.44	0.06	0.21	0.33
Credit, insurances	-0.02	-0.08	-0.16	0.04	0.13	0.19
Health	-0.03	-0.06	-0.09	0.12	0.25	0.31
Other market services	-0.08	-0.37	-0.67	0.2	0.78	1.13
Total market branches	-0.04	-0.22	-0.43	0.14	0.46	0.65
OTHER MACROECONOMIC RESULTS						
Current external balance (% of GDP)	0.09	0.33	0.52	0.02	0.12	0.13
Total employment (in thousands)	-1.29	-8.00	-16.45	5.32	17.49	25.29
Net lending/borrowing of the public authorities						
. million €-current prices	1357.95	2216.54	2829.52	205.96	37.7	238.13
. % of GDP	0.37	0.48	0.51	0.06	0.00	0.04

Source: HERMES

4.5. Sensitivity analyses

4.5.1. Impact of CDM flexibility

The Energy/Climate Package proposed by the European Commission gives the Member States the opportunity to obtain emission reduction credits through CDM flexibility mechanisms. This possibility is included in the *20/20 target scenario* where 25% of the reduction effort at EU level by 2020 is assumed to be implemented by CDM both in ETS and non-ETS. This ceiling translates for Belgium into an access to CDM credits (and/or annual emission allocations) in the non-ETS sector for the equivalent of 5.8% of 2005 emissions. This scenario combines also the annual access to CDM up to 3% of 2005 emissions specified in the EC proposal as well as the transfer of unused CDM user rights in other Member States (or of annual emission allocations) up to 2.8%.

The following sub-sections provide an evaluation of the effects of proposed flexibility on GHG emissions, RES production, energy imports and direct cost as well as an overview of the macroeconomic impact.

a. Impact on GHG emissions and RES production

Because the price of CDM emission credits is most likely to be lower than the marginal cost of GHG reduction within the EU territory, the use of CDM reduces the abatement effort in the Member States and brings down carbon prices for both ETS and non-ETS sectors at national level. To evaluate the impact of CDM, another scenario was built which is similar to the *20/20 target scenario* but does not allow for the use of CDM credits. This scenario, called *'without CDM'*, is characterized by higher carbon prices in both ETS and non-ETS sectors, namely 42 €/tCO_2 in both sectors (the carbon prices are respectively equal to 33.5 €/tCO_2 and 25 €/tCO_2 in the *20/20 target scenario* allowing for CDM).

Table 15 below illustrates the impact of CDM on GHG emissions. It shows, for instance, that total GHG emissions are 4.9% below the level of 2005 if CDM is not allowed, compared to 0.5% if CDM is part of the abatement options.

Table 15: Impact of CDM on GHG emissions and RES production, 20/20 target scenario, year 2020 (%)

			With CDM	Without CDM
Prices	ETS	CV (€/tCO_2)	33.5	42.3
	Non-ETS	CV (€/tCO_2)	25.0	42.3
	RES	RV (€/MWh)	49.5	44.3
Quantities	ETS GHG	wrt 2005 (%)	+11.7	+9.2
		wrt baseline (%)	-11.4	-13.3
	Non-ETS GHG	wrt 2005 (%)	-9.2	-15.0
		wrt baseline (%)	-12.4	-17.9
	Total GHG	wrt 2005 (%)	-0.5	-4.9
		wrt baseline (%)	-11.9	-15.8
	RES production	ktoe	4900	4780

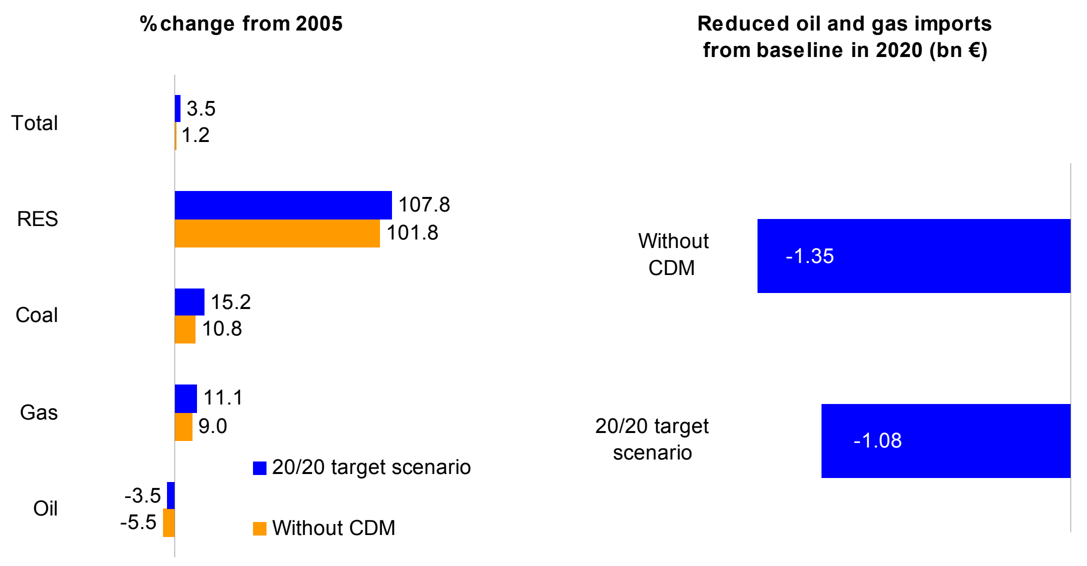
Source: PRIMES, NTUA

On the other hand, higher carbon prices required in the absence of CDM imply that the RES value decreases in order to meet the same RES target (i.e. 12.3%) because higher carbon prices bring about more energy savings and further development of RES. Without CDM, the RES value is estimated to be 44 €/MWh and RES production to be 4780 ktoe in 2020, compared to 49.5 €/MWh and 4900 ktoe respectively in the scenario in which CDM is allowed.

b. Impact on net energy imports

Figure 18 shows the impact of access to CDM emission credits on net energy imports. As expected, the increase in energy imports over 2005-2020 is lower when CDM is not allowed (+1.2% compared to 3.5%). Both the imports of fossil fuels and of RES are lower without CDM. These trends result from higher carbon prices and a lower RES value. Nonetheless, both scenarios assume the same percentage of RES production on the Belgian territory (i.e. 12.3%). This can be attributed to the fact that, in the case CDM is not allowed, the CV is higher and the FED thus decreases further. As a consequence, the total quantity of RES to achieve the same ratio can be lower.

Figure 18: Impact of CDM on net energy imports, 20/20 target scenario, year 2020



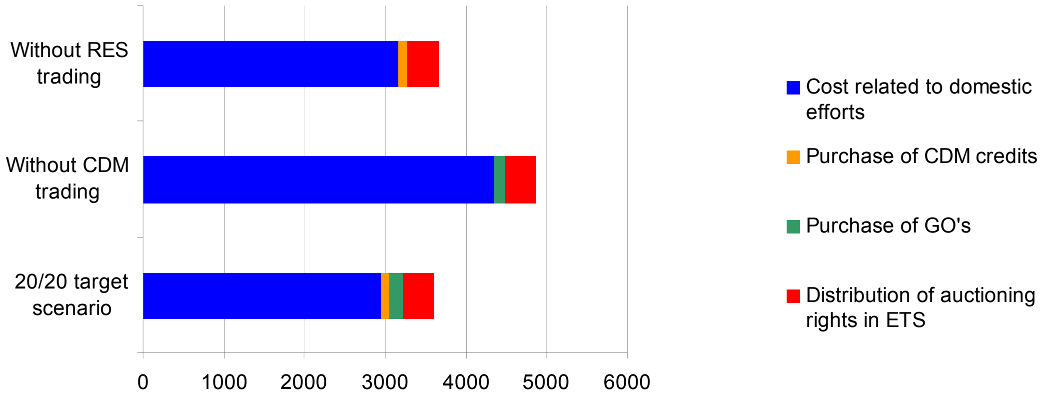
Source: PRIMES, NTUA

Access to CDM reduces then the benefit of the Energy/Climate Package in terms of reduced oil and gas imports. The benefit is estimated to be 1.08 billion € of 2005 in 2020 in the *20/20 target scenario* compared to 1.35 billion € in case of no CDM, i.e. a difference of 250 million € in 2020. However, one should not forget the significant cost reductions elsewhere in the economy as a result of access to CDM. This is the subject of the next section.

c. Impact on direct cost

Figure 19 shows that reducing emissions through CDM helps to decrease the direct cost in spite of the fact that emission credits from CDM have to be paid. The cost saving is estimated to be 1.3 billion € of 2005 in 2020 (i.e. the total direct cost is reduced by 40%). It is mainly due to the drop in costs related to domestic efforts (-32%) further to a significant decrease in carbon prices. Costs related to domestic effort represent about 80% of the total compliance cost in the *20/20 target scenario*.

Figure 19: Impact of CDM and RES trading on direct cost, 20/20 target scenario, year 2020 (mln € of 2005)

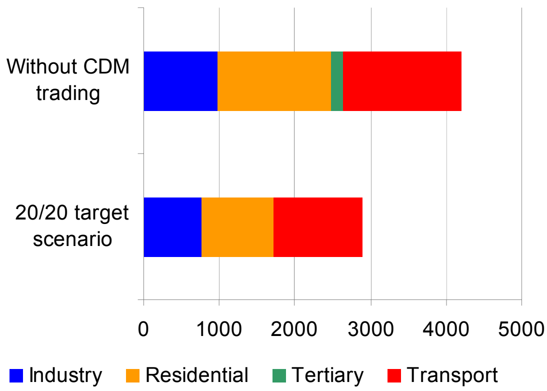


Source: PRIMES, NTUA, own calculations
NB: Purchase of CDM credits relates only to non-ETS.

d. Impact on energy related costs per sector

Meeting part of the GHG target through emission credits from CDM implies a smaller impact on energy prices and costs but above all on disutility costs (see Figure 20). The latter ensure about 80% of the total cost saving in 2020 (i.e. roughly 1 billion € of 2005). Cost savings are the most significant in the residential and transport sectors which bear the highest disutility costs. These two sectors contribute respectively to 40% and 30% of the decrease in costs related to domestic efforts further to the access to CDM. The absolute figures for the cost savings in 2020 are the following: 500 million € for the residential sector, 400 million € for transport, 200 million € for industry and 150 million € for the tertiary sector (€ of 2005).

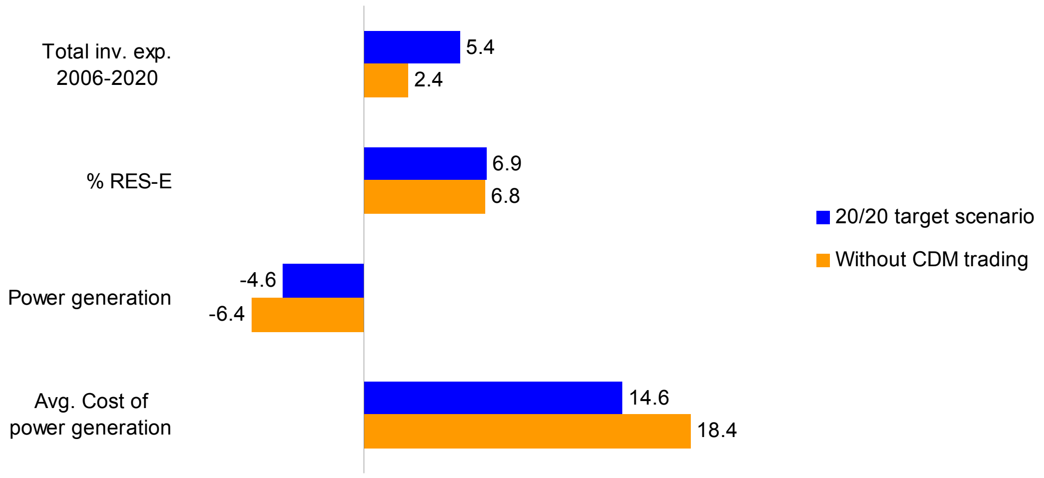
Figure 20: Impact of CDM on direct cost related to domestic efforts, per sector, 20/20 target scenario, year 2020 (mln € of 2005)



Source: PRIMES, NTUA (2008), own calculations

The following figure focuses on the impact of CDM on several cost indicators in the power generation sector.

Figure 21: Impact of CDM on several indicators in the power generation sector, 20/20 target scenario, year 2020 (% change compared to the baseline)



Source: PRIMES
NB: For the indicator '% RES-E', the change from baseline is expressed in percentage point.

In the *20/20 target scenario* in which CDM is allowed, the power sector, belonging to the ETS, faces lower carbon prices but slightly higher RES value than in the scenario without CDM trading. The net effect on the power sector is a less significant decrease in power production with respect to the baseline (-4.6% in 2020 compared to -6.4% without CDM) because of the smaller impact on the demand for electricity and a slighter increase in power generation costs (+14.6% in 2020 against +18.4% in case of no CDM). The former impact implies much higher investment expenditures over 2006-2020 compared to the baseline (+5.4% in 2020 against +2.4% without CDM). Finally, regarding the share of RES for electricity production, the results for the *20/20 target scenario* are not significantly different than for the 'without CDM trading' scenario: the increase in the RES value which pushes further the deployment of RES in the former scenario is almost exactly compensated by the rise in power generation.

e. Macroeconomic impact

When CDM is not allowed, the impact on the economy is different. Indeed, as carbon prices are higher in case of no CDM, more revenues are collected and the recycling policies are expected to have a more positive impact on the economy, especially when new public receipts are integrally used to reduce employers' contributions. This is confirmed by simulation results (see Table 38 in annex 6.6.1), though the final impact on GDP remains slightly negative by 2020 (-0.05%) with around 7500 new jobs created compared to the *20/20 target scenario*. When only ETS auctioning revenues are reinvested in the scenario or when no recycling occurs (see Table 38 and Table 39 in annex 6.6.1), the negative impacts are more significant at each level of the economy.

4.5.2. Impact of RES flexibility in Belgium

The proposed Policy Package also provides for the exchange of GO's among Member States that can count towards their individual RES target. This possibility is included in the *20/20 target scenario* where Belgium realizes 12.3% of RES domestically while the remaining 0.7% is achieved through RES trading.

A specific scenario, called *'without RES trading'*, was designed so as to evaluate the impact of RES trading on the direct cost in Belgium. It only differs from the *20/20 target scenario* in the fact that Belgium achieves its RES target of 13% fully domestically. More precisely, it is assumed that RES flexibility exists in the EU but that Belgium does not have access to it. As a result, the European renewable value is identical in all EU countries and remains close to the value of the *20/20 target scenario* (i.e. 49.5 €/MWh) so that the impact on the EU carbon prices is negligible. In the *'without RES trading'* scenario, the carbon prices in ETS and non-ETS are therefore assumed to be identical to the ones in the *20/20 target scenario*. The renewable value corresponding to the achievement of the 13% RES target on the Belgian territory is estimated to be 64 €/MWh.

Figure 19 illustrates the difference in direct cost induced by RES trading. The impact of the absence of RES trading is estimated to be maximum 70 million € in 2020. Costs related to domestic effort are 7% higher than in the case with RES trading (i.e. the *20/20 target scenario*).

5. 30/20 target scenario

To determine the *30/20 target scenario*, the approach chosen slightly differs from the one followed for the *20/20 target scenario*. The main reason is that the European Commission did not come up with concrete targets in its legislative proposals, neither for the ETS, nor for the non-ETS; it rather proposed counting rules.

In this part, the same indicators and graphs will be analysed as was done in the *20/20 target scenario*, following a similar subdivision and general approach. In Annex, some additional figures are shown that compare, for the three scenarios, a selection of parameters. Important to grasp the analyses performed in this part, is to keep in mind that the *30/20 target scenario* adopts a twin target (GHG emission reduction combined with RES development), no analysis on a single objective is reported in this chapter (nor in the entire study for that matter).

5.1. Description/rationale

Because of the lack of specific quantitative targets on Member State level, the design of the *30/20 target scenario* was based on information provided in the 2007 Impact Assessment regarding the necessary global reductions to reach the 2°C target (*Limiting Global Climate Change to 2 degrees Celsius*) and also on information on the expected changes in the international context that was collected at a meeting with the NTUA. According to the NTUA, oil prices are likely to change little in the multilateral -30% scenario, at least for 2020, because oil demand will remain high for the following reasons: the advanced developing countries have rather favourable growth perspectives and the transport sector will not be affected much during this time period. The biggest changes can be expected in the electricity sector, but since this sector only consumes little oil, no substantial revolution in oil prices is to be expected. Gas prices will not be largely affected either, because they are linked to the oil prices. Experts then estimate the subsequent carbon price on the international market to be around 30-35 €/tCO_2. At this value, the additional effort for the EU in the -30% scenario compared to the -20% scenario will mostly be realized by means of extra CDM. The choice to further investigate a scenario with a carbon value equal to 30 €/tCO_2 was also inspired by the fact that the proposals taken from the Energy/Climate Package foresee a linkage between the EU ETS and other national or regional cap and trade programs (as in the US for example).

The *30/20 target scenario* then simulates the European Commission's proposal for Belgium as estimated by the Steering Committee on the basis of best available knowledge[44]. For the non-ETS

44 Based on the application of the rules for the determination of non-ETS targets in the multilateral reduction scenario as laid out in the non-ETS legislative proposal. The analysis is based on shares in reductions between 2005 and 2020 while the Commission Services argue that the calculation needs to be based on the shares in reductions between 2013 and 2020. Since the 2013 "starting point" (which is proposed to be the average annual greenhouse gas emissions during the years 2008, 2009 and 2010) cannot be determined "ex ante", no exact determination of the reduction

target, this implies a reduction objective for Belgium in 2020 of 21% below 2005 levels. Regarding the ETS sector, the EU-wide cap will be further reduced to 1357 Mt CO_2 (compared to 1720 Mt CO_2 in the *20/20 target scenario*). All ETS companies together can make use of a supplemental amount of 133 Mt CO_2 CDM credits per year.

To sum up, the *30/20 scenario* is a reduction scenario in which a 30% reduction in greenhouse gases by 2020 compared to 1990 levels is attained at the European level and a 20% share of renewable energy in Gross Final Energy Demand by 2020 is reached for the EU as a whole, including a 10% share of renewable energy in transport in each Member State. At the Belgian level, the non-ETS, ETS and RES objectives in the *30/20 scenario* are as follows:

– First, in the non-ETS sector, it integrates the European Commission's proposal for GHG reduction in the Belgian non-ETS by 21% in 2020 compared to 2005 emissions.
– Secondly, the effort performed in the Belgian ETS sector depends on the cap that is determined at EU level (1357 Mt CO_2 in 2020). The general allocation rule in the -30% scenario for the EU allowances to companies is auctioning, so we assume a gradual increase to 100% auctioning of EU allowances over the period 2013-2020.
– Thirdly, on renewables, the scenario includes the Belgian target proposed by the Commission, namely a 13% share of renewable energy in Gross Final Energy Demand.

The carbon values that match this scenario are shown in Table 16. One notices that both ETS and non-ETS have a CV equal to 30 €/tCO_2[45] which is identical to the EU CV, and this for an obvious reason: this scenario allows for the use of flexibility mechanisms and intra-European trade. Because of the presence of trade and flexibility mechanisms, arbitrage possibilities are exploited causing the carbon values ultimately to level out amongst Member States.

The Renewable Value was fixed at 49 €/MWh[46], which corresponds to a share of 12.3% RES in Gross FED.

Table 16: Carbon and renewable values for Belgium, baseline, 20/20 and 30/20 target scenario, year 2020

	Baseline	20/20 target scenario	30/20 target scenario
Carbon value - ETS (€/tCO_2)	22	33.5	30
Carbon value - non-ETS (€/tCO_2)	0	25	30
Renewables value (€/MWh)	0	49.5	49

Source: NTUA

As can be noticed, the carbon and renewable values that characterize the *30/20 target scenario* are very close to the ones used in the *20/20 target scenario*. Therefore, one can already anticipate the

targets for the different Member States can be calculated.

45 This corresponds to the lower boundary as estimated by expert judgment. Since there is much uncertainty about the ambition's level of the international agreement and since this will have an influence on the carbon price, a sensitivity analysis based on a carbon value of 40 €/tCO_2 for both ETS and non-ETS was also carried out.

46 The reasoning behind this choice is the same as the one made for the *20/20 target scenario*.

impact on the Belgian energy system not to be too remote from the one discussed in 4.2. The main difference between the two scenarios lies in the amount of flexibility mechanisms used (the efforts realized on the Belgian territory in the *20/20* and *30/20 target scenario* are thus very similar).

5.2. Impacts on the energy system

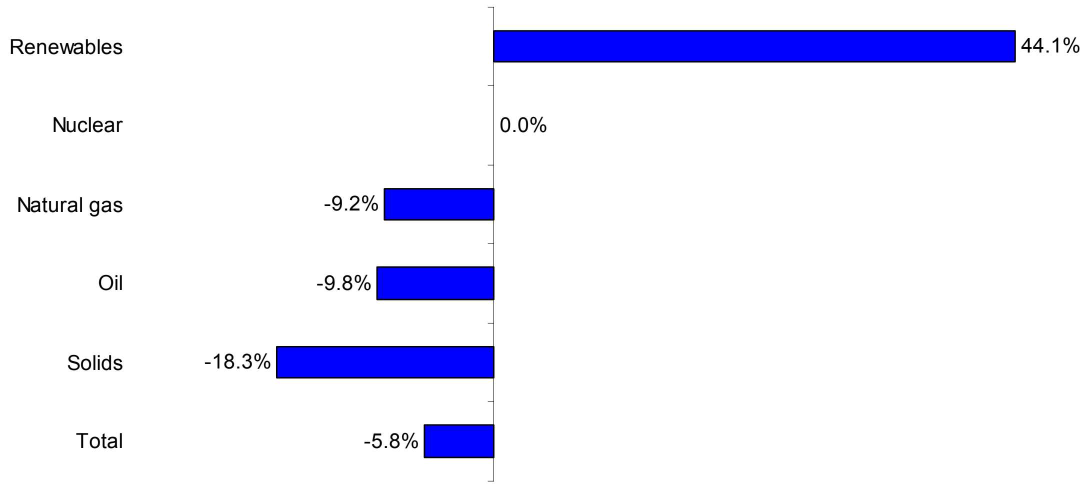
As in the part devoted to the *20/20 target scenario*, figures and analyses will be made with respect to the baseline (in some selected cases, a comparison of all 3 scenarios will be provided) and up to the year 2020. This reasoning is followed to clearly demonstrate the effort society has to make in a given year to met the goals set for 2020.

5.2.1. Gross Inland Consumption

A first impact studied is the effect the carbon and renewable value of the *30/20 target scenario* have on the Gross Inland Consumption (GIC). Two immediate consequences can be distinguished: first, the decrease in total energy demand and second, a fuel switch between the different energy sources. The effect on energy demand nevertheless prevails on the (rather limited) substitution effect. Compared to the baseline, the decrease in total energy consumption amounts to 6% in 2020[47]. Solid fuels support the largest dip, their consumption being cut by almost one fifth. The other fossil fuels also see their demand shrivelled by almost 10%. The only exception are the renewable energy sources: they progress by 44%. Nevertheless, this sharp increase does not make up for the losses borne by the fossil fuels, since the renewables only constitute a rather small part of the GIC (4% of total GIC in 2005, 10% in 2020).

47 The 6% decrease is with respect to the baseline in that same year; compared to the starting position in 2005, the GIC still increases with 1%, mainly due to a growth in consumption of solids (+17%) and natural gas (+11%). The solids' consumption rise is to be put on the account of the iron and steel industry, whilst the increase in natural gas can be attributed to all sectors.

Figure 22: Gross Inland Consumption, 30/20 target scenario, year 2020: % change compared to the baseline



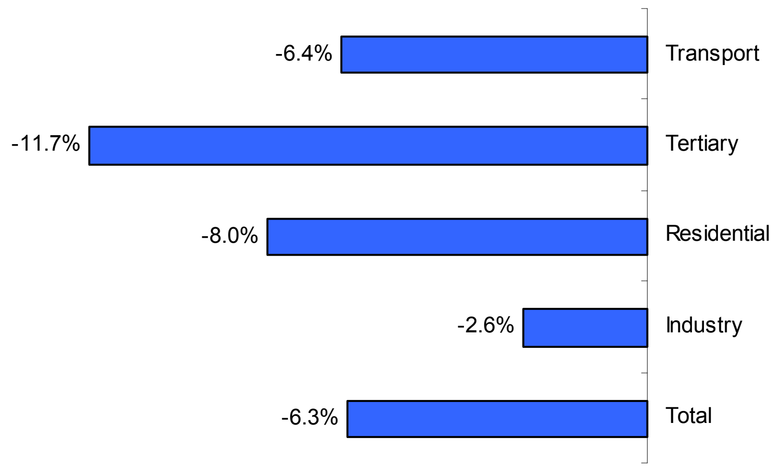
Source: PRIMES

It is worthwhile to notice that when both targets are imposed, both total demand and imports of all fossil fuels (see also Figure 28), including natural gas, decrease relative to the baseline. The imposition of the RES target (and matching RV) then prevents gas demand from increasing as a substitute for coal in power and steam generation: This finding takes the edge off the possible adverse effects that climate change actions can have on gas import dependence and, hence, on security of supply issues.

5.2.2. Final Energy Demand

The final energy demand is also affected: it is cut by slightly more than 6%. Tertiary supports the relatively biggest consequence of a GHG and RES target with a decrease of its final energy consumption by almost 12%, followed by households (8%) and transport (6%). The impact on industry seems to be small for reasons already explained in 4.2.2. Translating these percentages into absolute numbers, we see that energy savings in the first three sectors oscillate around 700 to 800 ktoe each, whereas they amount to about 350 ktoe in industry.

Figure 23: Final energy demand, 30/20 target scenario, year 2020: % change compared to the baseline

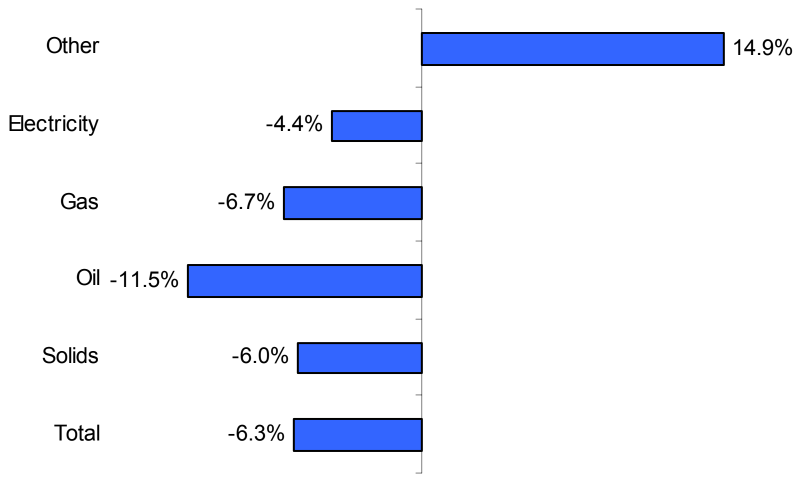


Source: PRIMES

NB: Transport does include aviation.

Looking at the same Final Energy Demand but this time decomposed into energy forms, we see that most energy vectors are cut back. Oil in particular sees its consumption diminished by 12% due to a lowered transport activity and a decrease in oil demand for heating purposes. Final Energy Demand also demonstrates the apparent uprise in renewables. Because of the presence of the combined target (and corollary CV and RV), renewables are being used where economically viable, even in final energy applications.

Figure 24: Final energy demand, 30/20 target scenario, year 2020: % change compared to the baseline



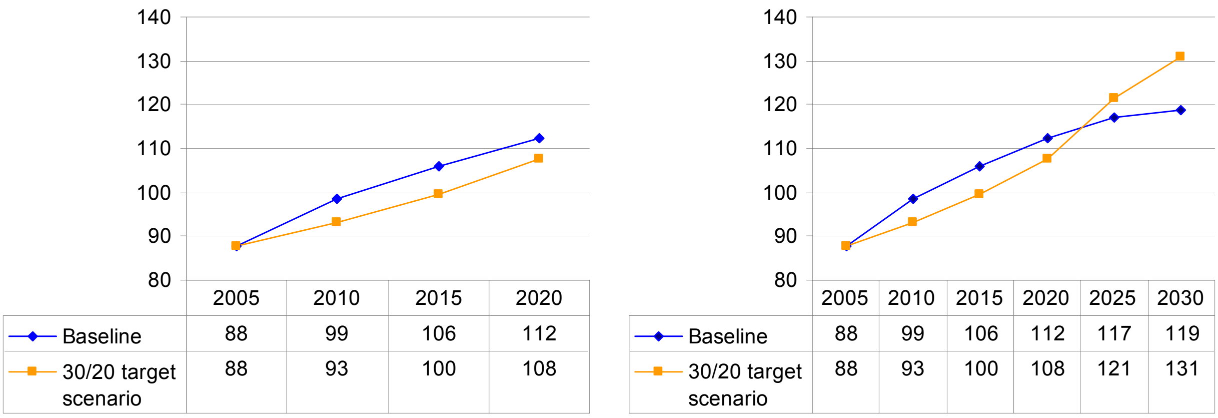
Source: PRIMES

NB: "Other" stands for renewable energy and heat.

5.2.3. Power generation

The need for power generation in the *30/20 target scenario* follows the demand for electricity[48], which seems to be affected by the 30% EU GHG reduction target and the 20% EU RES objective. The consequences can be split up in two time periods to show two main effects[49]. The first period reaches from 2005 to 2020. The principal effect is the reduction in electricity demand, as a general decrease in energy consumption can be felt (see also Figure 22). The second period, from 2020 to 2030, shown on the right hand side of Figure 25, displays another factor: fuel switching taking place between more expensive (e.g. oil) and relatively cheaper energy forms (e.g. electricity).

Figure 25: Called-up electrical power (TWh), baseline and 30/20 target scenario, evolution: period 2005-2020 and 2005-2030



	2005	2010	2015	2020
Baseline	88	99	106	112
30/20 target scenario	88	93	100	108

	2005	2010	2015	2020	2025	2030
Baseline	88	99	106	112	117	119
30/20 target scenario	88	93	100	108	121	131

Source: PRIMES, own calculations

This demand must be satisfied through a corresponding generation of electricity. In total, 102 TWh is produced in 2020, the decomposition being the same as in the *20/20 target scenario* (see Figure 10).

To wrap up the situation in the power sector, Table 17 shows a selection of sector specific parameters for the *30/20 target scenario*, next to the ones in the baseline.

Table 17: Indicators related to the power generation sector, baseline and 30/20 target scenario, year 2005 and 2020

	2005	2020 baseline	2020 30/20 target scenario
Efficiency for net thermal electricity production (%)	31.9	45.2	45.4
Net imports ratio (%)	6.9	5.1	5.4
% net electricity from CHP	7.4	25.0	25.0
% electricity from RES	4.7	12.4	19.1
Share of non-fossil fuels in net power generation (%)	59.5	44.1	52.3

48 This is so because imports of electricity are exogenously determined and do not change according to the scenario.
49 For a more elaborate explanation, see part 4.2.3.

Net installed power capacity (GW)	15.3	20.8	21.0
Carbon intensity (tCO_2/GWh)	235	245	204
Electricity (final demand) per capita (kWh/capita)	7675	9569	9149

Source: PRIMES

The evolution of the average efficiency of thermal electricity production is closely related to the technology mix. The remarkable increase in 2005-2020 both in baseline and the reduction scenario has to do with investments in combined cycle gas turbines (CCGT) that are characterized by a high conversion efficiency (close to 60% for new generation). The net imports ratio decreases somewhat over time due to lower net imports in both scenarios. Important to retain is that the level of net imports is exogenously fixed for all scenarios (and for all countries).

The share of non fossil fuels in electricity production combines two elements: nuclear energy, on the one hand, renewable energy sources, on the other. The share of nuclear electricity decreases steadily in both scenarios further to the decommissioning of nuclear plants after an operating lifetime of 40 years. On the contrary, the share of renewable energy sources goes up: representing only 5% in 2005, it reaches 12% in 2020 in the baseline and 19% in the *30/20 target scenario*. Similarly, the share of CHP (covering both fossil fuels and biomass based cogeneration) in electricity generation goes up steadily: from 7% in 2005, it reaches 25% in 2020 in both scenarios.

The installed power capacity increases by 36% over the period 2000-2020 in the baseline and slightly more in the reduction scenario (38%). This increase is required to meet the growth in electricity consumption in both scenarios. However, the power capacity increases at a higher pace than electricity demand. One reason is the moderate decrease in net electricity imports; another is the decline in the average utilisation rate of electrical capacities: in 2005, it was around 61%; in 2020, it is estimated to be 59% in the baseline and 55% in the *30/20 target scenario*[50].

As 19% of the electricity production in 2020 is provided by renewable energy sources, a special paragraph is dedicated to this energy source. Table 18 summarizes its net power generation and capacity in the *30/20 target scenario*, next to the percentage change from the baseline. As in the *20/20 target scenario*, we see that hydro and solar PV do not change with respect to the baseline (but they do with respect to 2005), wind and biomass and waste on the other hand grow considerably. The wind accumulation can be ascribed to offshore wind: the *30/20 target scenario* foresees an additional 1000 MW installed capacity in 2020, what boils down to approximately 2000 MW offshore installed by 2020[51]. Biomass and waste provide the largest part of RES based electricity production (almost 11 TWh in 2020).

50 The decrease in average utilisation rate (i.e. generation/(installed capacity x 8760 hours)) is due to the higher share of power capacities based on intermittent energy sources such as wind and solar.

51 This is what is foreseen to be potentially built on the North Sea Continental Shelf (Ministerial Council in Ostende, March 21 and 22, 2004).

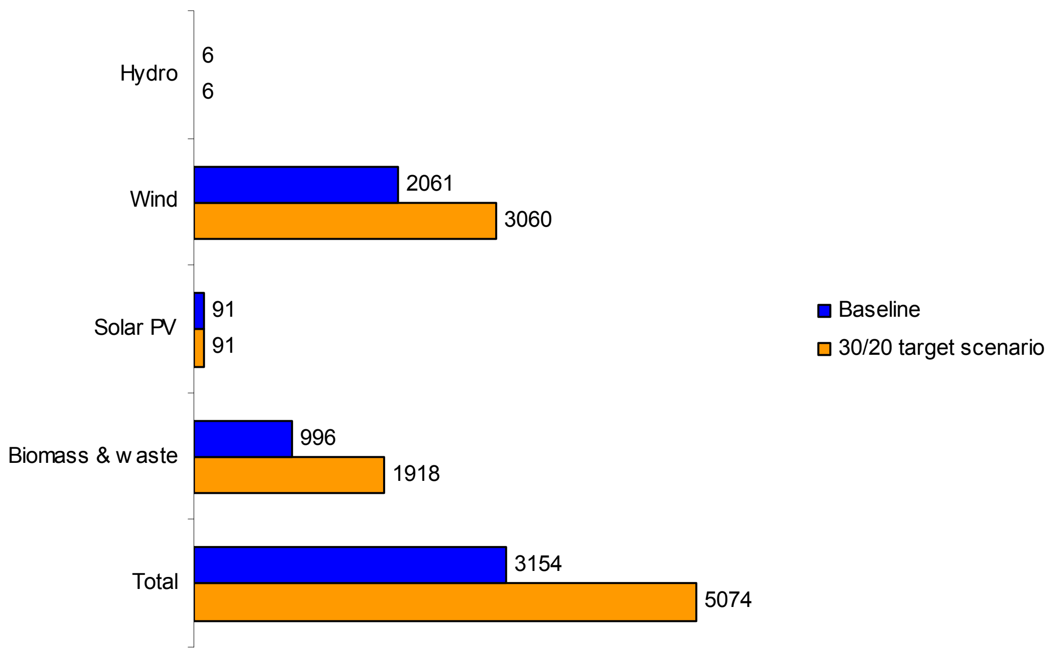
Table 18: Net power capacity (MW) and electricity generation (GWh), 30/20 target scenario, year 2020

	Net power capacity (MW)		Net electricity generation (GWh)	
	2020	% change compared to baseline	2020	% change compared to baseline
Hydro	108	0%	363	0%
Wind	3227	45%	8194	54%
Biomass and waste	2469	60%	10838	46%
Solar PV	93	0%	71	0%

Source: PRIMES, own calculations

As we are interested in the progression from the year 2005 onwards, Figure 26 shows the additional net installed RES power capacity for the baseline and the *30/20 target scenario*. Once again, we see that hydro and solar do not take off spectacularly: the former because of a limited potential in Belgium, the latter because costs, even with a RV of 49 €/MWh, seem to be prohibitive. Wind and biomass and waste, on the other hand, expand considerably in both scenarios, with an expected additional growth of both energy forms in the reduction scenario of approximately 1000 MW on top of the baseline. In total, the *30/20 target scenario* banks on an extra 5000 MW installed starting from the 2005 level (+/-1000 MW).

Figure 26: Net installed RES power capacity (MW), baseline and 30/20 target scenario, year 2020: difference from 2005

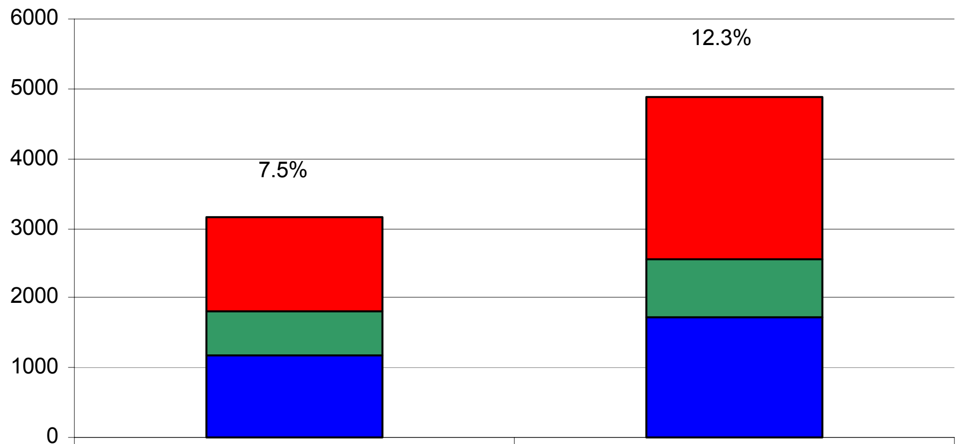


Source: PRIMES

5.2.4. RES in Gross Final Energy Demand

After this overview of renewable energy forms within the power sector, we follow a more general approach to determine the total share of RES in Final Energy Demand in the *30/20 target scenario*. As stated in part 3.1.4, a 13% share in Gross FED in Belgium should be reached by 2020 according to the January 2008 proposal of the European Commission. In the baseline, we saw that a 7.5% share or 3200 ktoe (36800 GWh) is obtained with current trends and policies in place. The *30/20 target scenario*, with the aid of the RV, steps up this effort and reaches 12.3%[52]. This boils down to an absolute amount of renewables in Gross FED of 4900 ktoe (57000 GWh). Figure 27 then splits up the different uses (heating and cooling[53], transport and electricity, or RES-H, RES-T and RES-E).

Figure 27: Renewables in Gross Final Energy Demand (ktoe), baseline and 30/20 target scenario, year 2020



	Baseline	30/20 target scenario
RES-H	1360	2337
RES-T	640	821
RES-E	1167	1726

Source: PRIMES

NB: RES-H encompasses at the same time the heat produced in biomass-based CHP as the biomass' and solar heat used for space and water heating.

52 For a more elaborate explanation as to how the RV and the 12.3% in the *30/20 target scenario* are determined, see part 5.1.

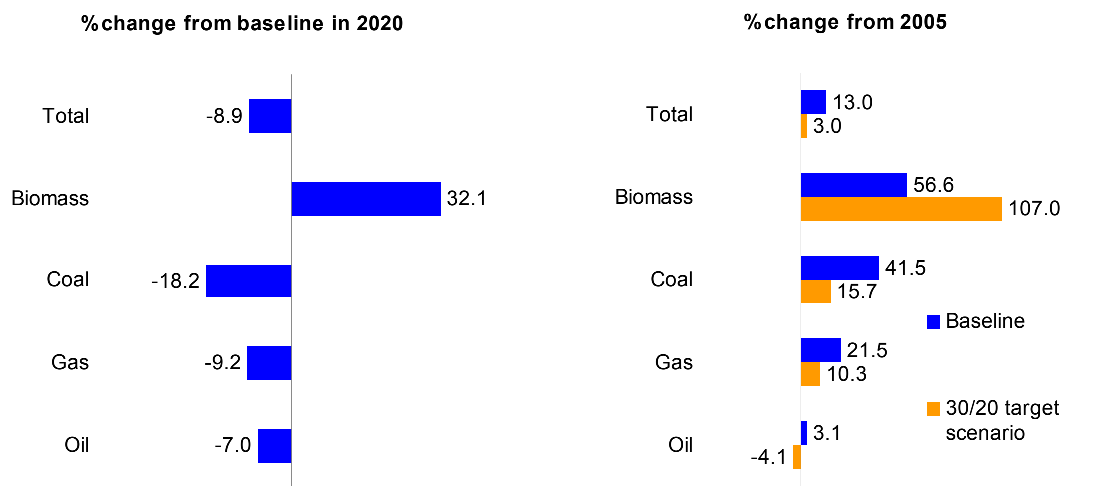
53 PRIMES categorises the electricity consumption (input) of heat pumps under "Final Energy Demand, Heating and cooling"; heat pumps therefore cannot be isolated from other electric heating and cooling uses. This might cause the percentage of RES-H to be slightly underestimated in the results shown.

Focusing on biofuels, we notice that the absolute amount of biofuels in the target scenario rises to 821 ktoe or 9.5% of transport[54] (liquids demand), compared to 640 ktoe in the baseline (6.9%) and starting off from a level of 0 ktoe in 2005. This means that without the use of a separate RES value for biofuels, the CV and RV suffice to reach the goal of 10%.

5.2.5. Import dependency

The GHG and RES targets also contribute to improve the security of our energy supply. The substitution in favour of carbon free resources (i.e. RES) and the decrease in energy consumption lead to reduced fossil fuel imports compared to the baseline. Total energy imports go down by 9% from baseline level in 2020. Consequently, total energy imports are projected to be 3% above 2005 levels in 2020, compared to 13% in the baseline.

Figure 28: Changes in net energy imports of Belgium, 30/20 target scenario, year 2020



Source: PRIMES

The changes in the Belgian energy system which characterize the *30/20 target scenario* bring about that the effect on energy demand and development of RES prevail against substitution effects among the fossil fuels. As a result, imports of all fossil fuels decrease compared to the baseline. The extent of the decline depends, however, on the type of fossil fuel. Coal drops by 18% from the baseline level in 2020; it is mainly due to a decrease in coal demand for power production. The decline amounts to 9% for natural gas, two thirds of which come from the power and heat sector and one third from energy efficiency gains. Finally, oil imports decrease by 7% essentially as a result of a lower demand in transport. Furthermore, the results show that, in this scenario, the Belgian economy will need less oil in 2020 than in 2005 (-4%). In monetary

54 9.5% stands for the biofuels' contribution being produced domestically (in Belgium). The deficit (remaining 0.5%) can be purchased through a mechanism of intra community trade, since the mandatory target of 10% renewable energy in transport on EU ground is honoured.

terms, the reduction in oil and gas imports translates into a saving of about 1.16 billion € in 2020 compared to the baseline (in € of 2005).

On the other hand, imports of biomass increase by 32% in 2020 compared to the baseline. This evolution results into a doubling of biomass imports in comparison with the situation in 2005. This result should however be put into perspective: the imports of biomass in the *30/20 target scenario* represent about 1% of total (net) energy imports in 2020. In the current model based analysis, imports of biomass only relate to inputs for domestic biofuel production. For all other types of biomass, imports are not modelled and supply comes exclusively from domestic production.

5.3. Impact on GHG emissions

The GHG emissions are projected to amount to 139.3 Mt of CO_2-equivalent in Belgium in 2020, about 13% down from baseline emissions in 2020 (159.7 Mt). This trend translates into a 1.4% reduction of GHG emissions from the 2005 level, instead of an increase by 13% as projected under the baseline. This figure only relates to emission reductions realized domestically. Access to CDM in the ETS and the non-ETS sectors allows Belgium to achieve further GHG emission reductions. In the non-ETS sector, the emission cap proposed is 21% below the level of 2005.

Table 19: GHG emissions in Belgium, 30/20 target scenario

	2020 (Mt of CO_2 eq.)	2020-change from baseline (%)	2020 vs. 2005 'domestic efforts' (%)	2020 vs. 2005 'total efforts' (*) (%)
All GHGs	139.3	-12.8	-1.4	-
All CO_2	117.4	-11.8	0.2	
ETS sectors	66.2	-11.0	12.2	-
ETS without aviation	60.7	-11.5	10.0	
Aviation	5.5	-5.3	44.0	
Non-ETS sectors	73.1	-14.3	-11.1	-21.0
Energy related CO_2	51.2	-12.8	-12.7	
Non-CO_2 GHGS	21.9	-17.6	-7.2	

Source: PRIMES, GAINS, NTUA

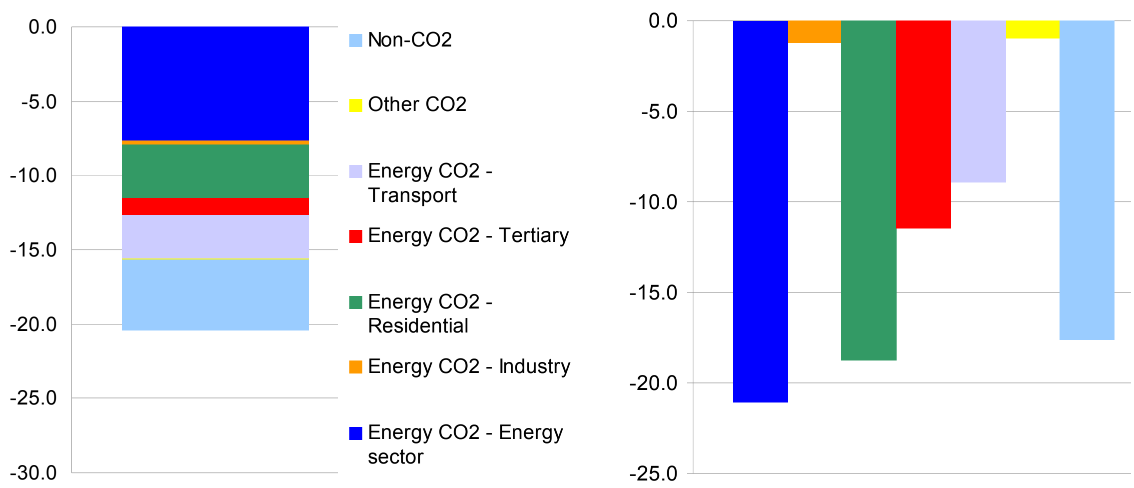
(*) i.e. domestic efforts plus resort to flexibility mechanisms (figures are only estimated for the non-ETS).

CO_2 emissions are projected to be close to the level of 2005 in 2020 (increase by 0.2%). However, this evolution corresponds to a decrease by 12% compared to the baseline emissions in 2020. By contrast, the emissions of non-CO_2 GHGs are projected to drop by 7% in 2020 compared to 2005. In the ETS sector, which experiences a carbon price of 30 €/tCO_2 in 2020, CO_2 emissions rise: 10% up from 2005 in 2020 without aviation, 12% if aviation is included in the ETS. In the non-ETS sector, the emission trend is opposite despite a similar carbon price: in 2020 GHG emissions are reduced by 11% compared to 2005. It is worth to underline that the emission trend in the ETS sector in Belgium is part of the European target. The emission increase is due to more limited emission reduction possibilities in Belgium, at a carbon price of 30 €/tCO_2, compared to the situation in other Member countries.

Above projections only relate to emission reductions realized domestically. Access to CDM in the ETS and the non-ETS sectors allows Belgium to achieve further GHG emission reductions. In the Energy/Climate Package, national targets are only specified for the non-ETS sector. The ETS sector is dealt with at the European level. It is therefore not possible to calculate the total GHG emission reduction Belgium will be able to achieve in 2020 without making additional assumptions for the national ETS sectors.

Figure 29 shows how the emission reduction effort realized domestically is allocated among the sectors (for energy related CO_2 emissions) and among the different categories of GHG.

Figure 29: GHG emission reductions, 30/20 target scenario, year 2020: difference from baseline (Mt CO_2 eq. (left) and in % (right))



Source: PRIMES, GAINS

NB: Transport includes international aviation; energy sector encompasses the power sector and other energy transformation sectors.

As in the *20/20 target scenario*, the major contributors to GHG emission reductions in Belgium, both in absolute and relative terms, are the energy sector, the residential sector and the non-CO_2 GHG. In the energy sector where CO_2 emissions are 21% down from baseline level in 2020, the major part of the reduction takes place in the power sector. In the residential sector, a partial shift to RES and electricity away from gasoil and natural gas, combined with large energy savings also results in significant CO_2 emission reductions. The reduction in non-CO_2 GHG emissions comes mainly from N_2O and more specifically from reduced fertilizer use in agriculture. In transport, industry and the tertiary sector, economic agents react to the carbon price and RES value by reducing the demand for energy services and/or by moving towards more efficient energy equipments. The changes in fuel mix have a comparatively smaller contribution to CO_2 emission reduction in these sectors.

5.4. Economic cost

The evaluation of the economic cost of the Energy/Climate Package for Belgium involves two complementary approaches. The first approach relies on the assessment of the direct cost (section 5.4.1) which encompasses two components: (a) the direct cost related to domestic effort assessed with PRIMES and GAINS and (b) the cost related to flexibility and to distribution of auctioning rights in the ETS. The second approach deals with the macroeconomic impact of the Package and relies on the HERMES model.

5.4.1. Direct cost

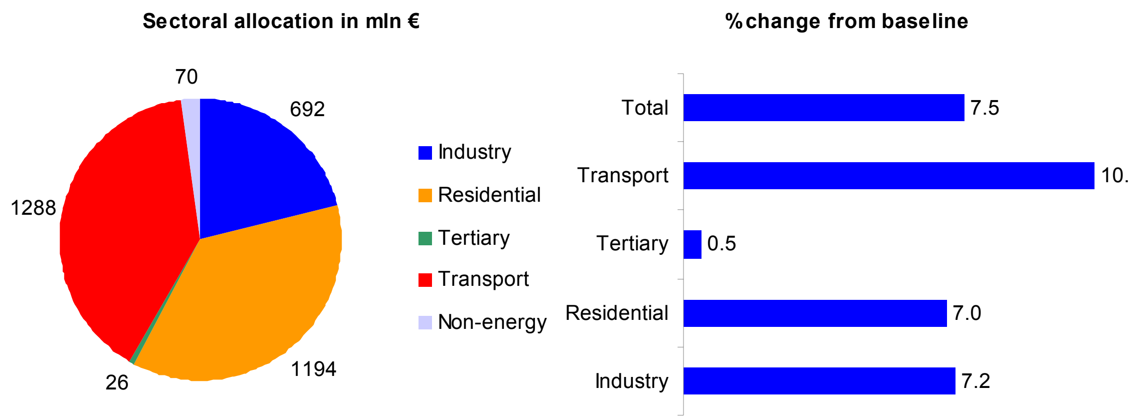
a. Direct cost related to domestic effort

This section describes the cost of achieving the domestic GHG emission reductions and the domestic RES production assessed in the *30/20 target scenario*. This cost encompasses the additional costs, compared to the baseline, experienced in the Belgian energy system due to the carbon price and the RES value (also referred to as energy related costs) and those resulting from mitigation measures for the non-CO_2 GHG. This cost excludes the purchase of CDM and AAU credits and GO's as well as the cost related to distribution of auctioning rights.

The energy related costs include the annual payment of investments in RES and energy efficient technologies as well as stranded costs when, for example, energy equipment is prematurely replaced, the changes in fuel and other variable operation costs and the costs of actions to remove barriers to energy efficiency improvement or to adapt energy consumption behaviour (the so-called disutility costs).

The direct cost related to domestic effort does not represent a net loss to GDP. For example, the investments in new energy technologies will foster the economic activity in particular sectors and the use of economic instruments for meeting the GHG target will bring about additional public revenues that could be recycled into the economy. To account for these feedback effects on the Belgian economy, the macro-sectoral model HERMES was used. The results of the evaluation of the full macroeconomic cost of the *30/20 target scenario* are described in section 5.4.2.

Figure 30: Direct cost related to domestic effort, 30/20 target scenario, year 2020



Source: PRIMES, NTUA

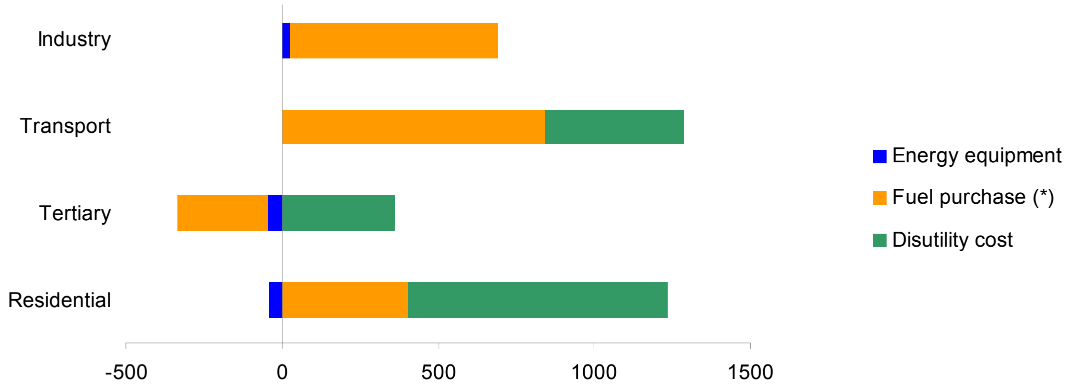
NB: The direct cost of domestic effort (i.e. additional cost compared to the baseline) amounts to 3.3 billion €. Costs are in € of 2005. Cost in transport only covers fuel costs.

The direct cost related to domestic effort in 2020 and its allocation among sectors is depicted in Figure 30. Cost figures reported under categories industry, residential, tertiary and transport refer to energy related costs while the cost under category non-energy relates to abatement measures for the non-CO_2 GHG and process related emissions of CO_2. The cost of domestic effort totals 3.3 billion € in 2020, 98% of which are energy related costs. It is equivalent to 0.8% of Belgium's projected GDP in 2020. The allocation of the effort among sectors is as follows: the transport sector takes the lead with 39%, followed by the residential sector (36%), industry (21%) and the tertiary sector (1%).

The domestic effort needed for meeting the emission reduction and RES deployment targets translates into an increase in energy related cost by 11% in transport and by 7% in industry and in the residential sector compared to baseline costs in 2020. The rise is much more limited in the tertiary sector (+0.5%). These changes include the cost increases supported by the power and steam sector. Indeed, in the model based evaluation, increases in average power production cost are transferred to electricity prices paid by the final consumers, affecting the energy related cost of the final demand sectors.

The cost related to domestic effort involves energy equipment costs, fuel purchase costs (where fuel also encompasses electricity and steam) and disutility costs. The allocation of additional costs among these three cost categories is shown in Figure 31 for each final demand sector. The disutility costs represent 51% of the additional cost; these costs are particularly high in the residential sector. The concept of disutility cost (or hidden cost) is explained in Capros et al., June 2008 Report, pp 27-28. In a nutshell, the disutility cost reflects the evidence from statistics that consumers do not act as expected by engineering-oriented analysis which points to energy savings with zero or even negative costs, the so-called no-regret energy saving potential. This observed behaviour is explained by factors such as lack of information, market barriers, less comfort, etc. The disutility cost is only relevant for the residential, tertiary and transport sectors. For industry, changes in energy consumption patterns and equipments are assumed to result from cost-efficient calculation of return on investments, etc.

Figure 31: Direct cost related to domestic effort, per sector and category, 30/20 target scenario, year 2020 (in mln € of 2005)



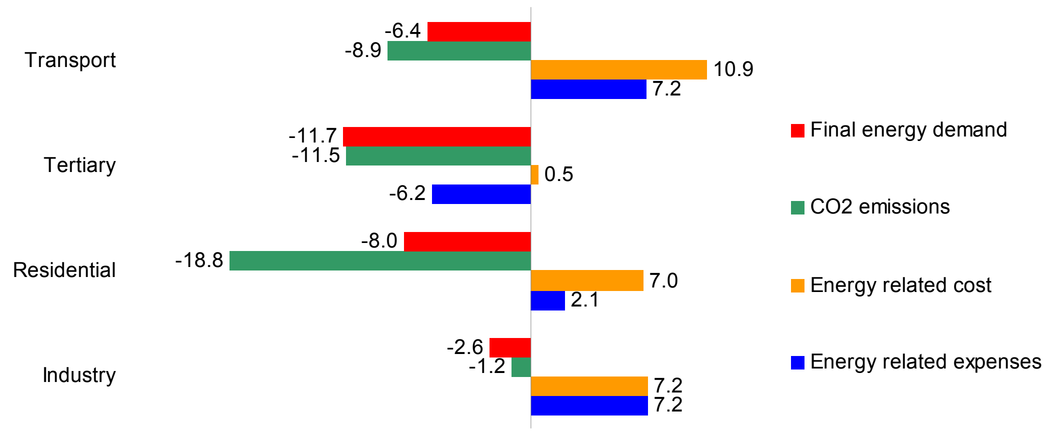
Source: PRIMES, NTUA
(*) Fuel purchase costs relate to all energy sources (fossil, electricity, steam, RES).
N.B. Direct cost represents additional cost compared to baseline.

For industry, the addional cost comes mainly from the purchase of energy commodities, of which more than 50% relate to electricity and steam. In transport, the evaluation only involves fuel purchase and disutility costs: the former represents two thirds of the additional cost and the latter the remaining third. The additional cost in the tertiary sector is negligible as the disutility costs are almost fully counterbalanced by the decrease in equipment and fuel costs. Finally, the additional cost in the residential sector is dominated by the disutility cost (70%) and to a lesser extent by the increase in fuel purchase costs. The latter increase is both due to the rise in electricity and fossil fuel prices.

The model based evaluation of costs is so that changes in electricity prices are related to changes in average electricity production costs. In the *30/20 target scenario*, the power sector faces higher carbon prices than in the baseline and is also influenced by the RES value. As a result, power generation costs increase compared to baseline. The rise is estimated to be about 13% in 2020.

The following figure puts the relations between costs and decreases in CO_2 emissions and energy consumption into perspective. The difference between energy related *cost* and energy related *expenses* is the disutility cost. Although the disutility cost is a real cost supported by the economic agents or the economy as a whole, it is not, strictly speaking, a spending of the energy consumers. Energy related expenses therefore only include equipment and fuel costs.

Figure 32: Sectoral indicators, 30/20 target scenario, year 2020: % change compared to the baseline



Source: PRIMES, NTUA

The figure shows that industry bears relatively high additional costs (+7.2%) compared to achieved reductions in energy consumption (-2.6%) and in CO_2 emissions (-1.2%). This result reflects the rather low fuel substitution possibilities and the quite high level of energy efficiency of the sector. These are results for industry as a whole. The impact of the *30/20 target scenario* on costs, CO_2 emissions and energy consumption varies according to the industrial sector and in particular between the energy intensive sectors and the others (cf. Section 4.4.1).

On the opposite side, the rise in energy expenses is relatively low in the residential sector (+2.1%) and even negative in the tertiary sector (-6.2%) compared to the impact on energy consumption (-8% and -11.7% respectively) and CO_2 emissions (-18.8% and -11.5% respectively). In the residential sector, the remarkable drop in CO_2 emissions comes from fuel substitution in favour of RES and electricity and from energy savings. All in all, energy related expenses per household are estimated to be 90 € up from the baseline in 2020 (compared to 50 € in the *20/20 target scenario*). In the tertiary sector, important energy saving potential is identified whereas fuel substitution possibilities are projected to be small. The shrink in energy related expenses compared to the baseline results from the fact that higher expenses in purchasing more efficient energy equipment are more than counterbalanced by savings in fuel costs (electricity included). Finally, fuel substitutions in transport favour mainly the biofuels, as part of the EU Energy/Climate Package. The response of transport to the carbon price goes also through vehicle efficiency improvement and activity reduction.

b. Total direct cost

The total direct cost is the sum of the direct cost related to domestic effort (see section 5.4.1.a above) and costs related to flexibility. The latter involve the purchase of CDM and AAU credits and the purchase of GO's. Due to the uncertainties on the use of CDM in the ETS sector in the international context surrounding the *30/20 target scenario*, we were not able to estimate the costs related to distribution of auctioning rights in ETS[55]. Table 20 shows the estimation of the direct cost of the *30/20 target scenario* in 2020, i.e. additional cost compared to the baseline.

Table 20: Total direct cost in 2020, 30/20 target scenario

	In % of GDP	In million € of 2005
Cost related to domestic effort	0.80	3300
Purchase of CDM and AAU credits in non-ETS	0.06	240
Purchase of GO's	0.04	150
Total direct cost (*)	0.90	3690

Source: PRIMES, NTUA, own calculations

(*) These figures are not comparable to the ones reported in Table 9 because they do not include the costs related to distribution of auctioning rights in ETS.

N.B. Direct cost represents additional cost compared to baseline.

In the *30/20 target scenario*, the non-ETS reduction target for Belgium is estimated to be 21% in 2020 compared to the 2005 level. Further to a carbon price of 30 €/tCO_2 imposed on the non-ETS sector, emissions are domestically reduced by 11% in 2020 from 2005 levels. The difference (i.e. 10%) is realized by means of CDM coming from the annual CDM user rights for Belgium that amount to maximum 6.2% of its 2005 non-ETS emissions on the one hand, transfer of unused CDM rights from other Member States on the other. Assuming that the CDM price is the same as the carbon price for the non-ETS sector (i.e. 30 €/tCO_2), the purchase of CDM credits is calculated to be 240 million € which is equivalent to 0.06% of the GDP in 2020.

Similarly, the purchase of GO's is estimated on the basis of the difference between the proposed target of 13% for Belgium and the domestic RES share of 12.3%, and a GO price equal to the RES value in 2020 (i.e. 49 €/MWh). This computation leads to a number of 150 million € which is equivalent to 0.04% of the GDP in 2020.

The total direct cost of the *30/20 target scenario* (excluding the cost related to the distribution of auctioning rights in the ETS) is projected to amount to 3.7 billion € in 2020, i.e. 0.9% of the GDP.

5.4.2. Macroeconomic impact

As stressed in the previous sections, the direct cost does not account for the feedback effects on the Belgian economy and its sectors. From a macroeconomic perspective, it should be taken into account that the higher energy prices would imply changes in agents' behaviour and demand level resulting from the rise in costs and prices. Also, the investments in energy efficient equipment and in new technologies are not just costs for households and firms, they generate revenues for the sectors (building, manufacturing…) that produce this equipment. Furthermore, the additional public revenues generated by e.g. the auctioning of emission allowances can have strong impacts on the cost of labour or on investments, depending on the way these revenues are used. To account for these feedback effects, the macro-sectoral model HERMES was used.

55 A rough estimation based on several hypotheses leads to a cost ranging from 340 to 800 million € in 2020.

As in the part devoted to the *20/20 target scenario*, we also present the ex ante effects of the *30/20 target scenario*, namely the impact on energy prices, the increase in public receipts and the modification of the international context.

Table 21 presents the ex ante impacts of the introduction of the carbon value on the main energy prices. Compared with the figures of Table 10, the *30/20 target scenario* generally has a higher impact on the energy prices in 2020 except for solid fuels and natural gas consumed by industry, and for electricity where the price of low tension electricity increases by +11.5% (instead of +12.3%). However, more inflation is generated with respect to the baseline in the average energy price in 2020 (+13.4% versus +12.7%).

Table 21: Impacts of carbon values on energy prices, 30/20 target scenario (% change from baseline)

	2010	2015	2020
Solid fuels			
(a) Households and services	17.2	20.9	25.3
(b) Industry	57.9	72.5	86.2
Liquid fuels			
(a) Gasoline	4.1	5.6	7.2
(b) Diesel oil	6.0	7.9	9.7
(c) Fuel for heating	11.2	14.9	18.3
Natural gas			
(a) Industry	9.9	12.2	14.5
(b) Households	8.4	10.9	13.6
Electricity			
(a) High tension	9.1	12.4	16.5
(b) Low tension	4.4	7.4	11.5
Average energy price	7.6	10.4	13.4
Of which households	6.3	8.6	11.1

Source: PRIMES, HERMES

The total public revenues collected in the *30/20 target scenario* (see Table 22) amount to 4.93 billion in 2020, with 1.48 billion coming from auctioning rights by the ETS sector and 3.45 billion from the introduction of the carbon value in the non-ETS sector. Proportionally, these public receipts represent 0.90% of GDP. As the non-ETS carbon value is higher here than in the *20/20 target scenario*, it generates more receipts. The contribution of the ETS sector in 2020 is also higher in the *30/20 target scenario* as, though the ETS carbon value is lower, 100% of auctioning revenues is now available for the recycling policies at the end of the period[56]. The new public receipts shown in the table are gross values. The amount used for recycling depends on the amount used for the purchase of flexible mechanisms (CDM and GO).

56 In the 20/20 target scenario, only 55% of the yearly auctioning revenues is available for recycling, while in the 30/20 target scenario, the share is growing linearly over the simulation period, starting with 20% in 2013, then 42% in 2015 and reaching 100% in 2020.

Table 22: New public receipts, 30/20 target scenario (in bn €-current prices)

	2010	2015	2020
(1) Industry	0.00	0.41	1.48
(2) Services	0.58	0.93	1.51
(3) Households (lighting, heating)	0.52	0.55	0.84
(4) Transport	0.52	0.74	1.10
(a) Households	0.20	0.30	0.43
(b) Firms	0.32	0.44	0.67
Total	1.63	2.63	4.93
In % of GDP	0.44	0.58	0.90

Source: HERMES

Impacts on Belgian potential export markets and international import/export prices have also been evaluated with NEMESIS. These impacts are not significantly different from those computed in the case of the *20/20 target scenario* (as much more flexibility has been introduced in the *30/20 target scenario*).

The macroeconomic impact of the *30/20 target scenario* is now presented according to two recycling modes: no recycling of new public receipts on the one hand, full recycling of new public receipts in reductions of social contribution paid by employers on the other. The results of these two recycling options indicate a possible range of the impacts on the Belgian economy; the actual impacts could lie in between. The results of the other recycling options are available in Annex 6.6.2.

a. No recycling of new public receipts

In this first option (*no recycling policy*), the auctioning and taxes revenues collected are not redistributed into the economy but serve to decrease the public debt. Table 24 (left part) summarises the simulation results, with the same presentation structure as Table 14. Unless stated otherwise, figures refer to the percentage change between the results of the *30/20 target scenario* and the baseline results for that year. The model enlightens a negative impact of the selected policy on the economic activity, caused by the increase in energy prices and the decrease in potential markets. In 2020, the cut in GDP with respect to the baseline reaches 0.50% (or 0.045% of average annual loss), but this fall is not far from the one obtained in the *20/20 target scenario* without recycling policy (-0.45%). The main explanation lies in the fact that the CVs are very close to one another in both scenarios, so that domestic demand and its various components react very similarly to the policy shock. Firm investment is the most affected demand component and loses 1.69% with respect to the baseline in 2020. At the same time, household consumption is expected to lower by 1%, mainly as the result of the cut in real disposable income (-1.25%). Also, the no recycling policy generates a rise of 1.14% in the deflator of private consumption in 2020, while the health index only increases by 1%. The model evaluates the fall in the energy demand expenditures resulting from the energy price increase at -3.29%.

Exports are also negatively affected by the no recycling policy and go down by 0.59% with respect to the baseline in 2020. International perspectives are indeed less attractive and export prices rise due to higher production costs (higher energy prices) and higher international prices. For imports, the fall is estimated at -0.79% in the context of a weaker energy demand in particular, and a weaker domestic demand in general (hence less demand for imports). Nevertheless, the more intensive use of flexibility mechanisms allowed for in the *30/20 target scenario* probably prevents Belgian exports from falling deeper, and may also explain why the drop in imports is quite similar to the one obtained in the no recycling policy of the *20/20 target scenario*.

Furthermore, with respect to the baseline, around 17,440 cumulated jobs are lost in 2020 as the direct result of the higher energy costs and the drop in economic activity. This cut amounts to 0.38% of job reductions with respect to the baseline. Productivity per head decreases by 0.11% in 2020 as value added is more depressed than employment. Inversely, unit labour costs go up after the policy shock (+1.01% in 2020) because total wages are increasing (caused by inflation) and value added is decreasing. Besides, the share of gross operating surplus in the value added lowers by 1.35% in 2020.

The sectoral impact on production and employment of the no recycling policy is heterogeneous. The deepest fall is observed in the energy sector, where production loses 3.42% in 2020. In the manufacturing industry, production is reduced by 0.94% with respect to the baseline, and the sectors of intermediary goods and consumption goods are specifically suffering much. For construction, the percentage of production loss amounts to -0.89% in 2020. On the services side, credit and insurances is much affected (-1.30%) while the effects on the health sector are quite limited (-0.08%). Production in agriculture is cut by 1.78% as the result of the high sensitivity of this sector to (downwards) international demand.

Job reductions in percentages are spread differently according to sectors. In 2020, the most affected one is construction (-1.01%) followed by energy (-0.91%) and other market services (-0.71%). In the manufacturing industry, the negative effects of the no recycling policy on employment are less pronounced (-0.34%) and in the health sector, the impact is the lowest (-0.10%).

b. Full recycling of new public receipts in reductions of social contribution paid by employers

In the *full recycling policy*, new public revenues (coming from the auctioning rights and from the potential non-ETS revenues) are used to reduce social contributions paid by employers.

The impact of the recycling policy on the social contributions paid by the different sectors is shown in Table 23. The amounts of revenues recycled are the new public revenues as outlined in Table 22, reduced by the amounts used for the purchase of flexibility mechanisms. Again, the reduction has been applied linearly to legal employers' social security contributions rates. The total reduction would amount to 4.49 billion in 2020, or 8.44% of total social security contributions paid by employers.

Table 23: Reduction in social contributions paid by employers, 30/20 target scenario, full recycling policy

	In million €-current prices			In %		
	2010	2015	2020	2010	2015	2020
Energy	-31	-47	-77	-2.64	-3.42	-4.69
Intermediary goods	-154	-227	-359	-4.29	-5.53	-7.61
Equipment goods	-100	-146	-224	-4.71	-6.05	-8.33
Consumption goods	-123	-177	-268	-4.93	-6.32	-8.66
Construction	-115	-183	-305	-5.13	-6.64	-9.23
Transports and communication	-162	-256	-436	-4.44	-5.81	-8.01
Trade, hotels, restaurants, ...	-283	-464	-788	-4.82	-6.28	-8.74
Credit and insurances	-114	-169	-273	-4.46	-5.74	-7.94
Health care	-218	-385	-705	-5.30	-6.92	-9.75
Other market services to households and services	-327	-575	-1053	-4.81	-6.24	-8.70
Total	-1627	-2628	-4488	-4.66	-6.06	-8.44

Source: HERMES

The macroeconomic results of the *full recycling policy* are taken into review (see Table 24, right part).

The impact on GDP of the increase in the price of energy products is evaluated at -0.12% with respect to the baseline in 2020. But again the effects are different according to macroeconomic aggregates.

Household consumption benefits from the recycling of public revenues in the short run. The impact of the variant is slightly positive in 2010 (+0.03%) because the fall in the real disposable income is more than compensated by the decrease in unemployment. The impact becomes neutral in 2015 but reveals to be negative at the end of the period (-0.11%). Actually, in 2020, the cut in real disposable income is more pronounced as inflation rises. On the firm side, investments decrease less than in the no recycling option. The reduction of social contributions of employers lowers the costs of production but these are imputed by new wage costs due to growing employment. Furthermore, firms face a lower demand.

Belgian trade with other countries suffers less with the full recycling simulation than under the no recycling assumption. In 2020, exports are cut by 0.48% with respect to the baseline, and imports fall by 0.55%. The positive effects of the *full recycling policy* are, however, more pronounced for imports in 2020, as energy demand goes down by 3.07% (instead of 3.29% in the no recycling policy), and domestic demand only falls by 0.22% (versus 0.83%). In a more unfavourable context, exporting firms have to support the decrease of potential markets and the rising of international prices. Again, less inflation is generated with the *full recycling policy* (+0.68% in 2020 for the deflator of private consumption, +0.52% for the health index).

Thus, the *full recycling policy* has a positive impact on employment which rises by +0.57% with respect to the baseline in 2020. This means that around 26,370 cumulated new jobs are created. Productivity per head is severely decreasing with the upwards move of employment (-0.81%). The full recycling policy does not affect value added (intermediary consumption and production both decrease roughly at the same pace) but implies a lower amount of total wages with respect to the baseline. Consequently, unit labour costs decline (and as firms face lower wage costs per head, they are encouraged to recruit).

At the sectoral level, production is reduced by the *full recycling policy* but the impact is less negative than when new public revenues would not have been recycled. For energy, the fall in production is -3.01% in 2020 while agriculture lowers by 0.86% and intermediary goods by 0.42%. Actually, the full recycling policy largely contributes to attenuate the effect of the rise in energy prices in all sectors of the economy. Besides, in equipment goods and transports and communication, the effect is slightly positive over the simulation period. In the health sector, production appears not to be sensitive to the redistribution of new public receipts.

Most sectors of the economy benefit from the *full recycling policy* in terms of employment. Sectors of equipment goods, consumption goods and other market services experience a more than 1% increase with respect to the baseline. Growth rates are less pronounced but appreciable in trade, credit and insurances, and health (between +0.21% and +0.35%). Jobs are however lost in the sectors of energy (-0.53%) and agriculture (-0.02%).

Comparing these sectoral results with the ones obtained in *the 20/20 target scenario*, it appears that production is more depressed in all sectors after the full recycling policy (except in credit and insurances), while employment rises more in services and construction, but rises less in industry.

Table 24: Macroeconomic results, 30/20 target scenario, no recycling policy vs. full recycling policy

% change the baseline	No recycling of public receipts			Full recycling of public receipts		
	2010	2015	2020	2010	2015	2020
MAIN MACROECONOMIC RESULTS						
Total production	-0.15	-0.49	-0.89	-0.04	-0.13	-0.33
Energy (Final expenditures, in 2000 prices)	-0.91	-2.06	-3.29	-0.89	-1.96	-3.07
Demand components (volumes)						
Households consumption	-0.10	-0.48	-1.00	0.03	0.00	-0.11
Investments	-0.15	-0.75	-1.25	-0.13	-0.52	-0.65
of which Firms	-0.21	-1.09	-1.69	-0.18	-0.86	-1.06
Total domestic demand	-0.10	-0.44	-0.83	-0.02	-0.12	-0.22
Exports of goods and services	-0.10	-0.32	-0.59	-0.08	-0.23	-0.48
Imports of goods and services	-0.12	-0.44	-0.79	-0.12	-0.33	-0.55
GDP	-0.07	-0.27	-0.50	0.02	-0.01	-0.12
Deflator of private consumption	0.56	0.95	1.14	0.44	0.56	0.68
Health index	0.45	0.82	1.00	0.33	0.41	0.52
Total employment						
. in thousands	-1.29	-7.55	-17.44	5.30	15.90	26.37
. in %	-0.03	-0.17	-0.38	0.12	0.35	0.57
Productivity per head (market branches)	-0.04	-0.11	-0.11	-0.12	-0.43	-0.81
Unit labour cost (Market branches)	0.38	0.85	1.01	-0.79	-0.73	-0.88
Real disposable income	-0.38	-0.72	-1.25	-0.28	-0.31	-0.48
Gross operating surplus of firms (ratio)	-0.18	-0.70	-1.35	0.61	0.20	-0.14
MAIN SECTORAL RESULTS						
PRODUCTION (volumes)						
Agriculture	-0.31	-1.13	-1.78	-0.07	-0.46	-0.86
Energy	-0.80	-2.19	-3.42	-0.77	-1.97	-3.01
Manufacturing industries	-0.19	-0.54	-0.94	0.00	-0.01	-0.23
. Intermediary goods	-0.24	-0.62	-1.15	-0.05	-0.07	-0.42
. Equipment goods	-0.12	-0.37	-0.46	0.03	0.03	0.04
. Consumption goods	-0.19	-0.59	-1.07	0.03	0.03	-0.23
Construction	-0.11	-0.47	-0.89	-0.06	-0.14	-0.22
Transports and communication	0.00	-0.22	-0.57	0.12	0.15	0.01
. Transport by rail	0.01	-0.11	-0.33	0.08	0.09	0.00
. Road transport	-0.13	-0.47	-0.91	-0.01	-0.10	-0.35
. Water and air transport	-0.15	-0.63	-1.23	-0.01	-0.18	-0.56
. Other transports and communication	0.07	-0.09	-0.37	0.18	0.28	0.22
Trade, hotels, restaurants, ...	-0.04	-0.30	-0.66	0.08	0.09	-0.06
Credit, insurances	-0.22	-0.63	-1.30	-0.07	-0.05	-0.37
Health	0.00	-0.03	-0.08	0.01	-0.01	-0.09
Other market services	-0.07	-0.35	-0.69	0.01	-0.01	-0.14
Total market branches	-0.15	-0.51	-0.92	-0.03	-0.11	-0.32
EMPLOYMENT						
Agriculture	0.00	-0.05	-0.16	0.01	0.01	-0.02
Energy	-0.22	-0.45	-0.91	-0.20	-0.26	-0.53
Manufacturing industries	-0.01	-0.07	-0.34	0.04	0.48	0.74
. Intermediary goods	-0.01	-0.11	-0.43	0.01	0.12	0.03
. Equipment goods	-0.03	-0.09	-0.12	0.04	0.51	1.19
. Consumption goods	0.00	-0.02	-0.38	0.07	0.78	1.11
Construction	-0.12	-0.54	-1.01	0.44	0.50	0.72

% change the baseline	No recycling of public receipts			Full recycling of public receipts		
	2010	2015	2020	2010	2015	2020
Transports and communication	0.03	-0.04	-0.18	0.24	0.52	0.70
. Transport by rail	-0.07	-0.34	-0.60	0.20	0.54	0.80
. Road transport	0.11	0.07	-0.09	0.41	0.87	1.15
. Water and air transport	0.04	-0.14	-0.49	0.27	0.72	1.24
. Other transports and communication	0.01	-0.03	-0.12	0.16	0.32	0.41
Trade, hotels, restaurants, ...	-0.01	-0.18	-0.45	0.06	0.19	0.33
Credit, insurances	-0.02	-0.07	-0.16	0.04	0.12	0.21
Health	-0.03	-0.07	-0.1	0.12	0.22	0.35
Other market services	-0.08	-0.36	-0.71	0.20	0.70	1.19
Total market branches	-0.04	-0.20	-0.46	0.14	0.42	0.68
OTHER MACROECONOMIC RESULTS						
Current external balance (% of GDP)	0.09	0.30	0.54	0.02	0.11	0.16
Total employment (in thousands)	-1.29	-7.55	-17.44	5.03	15.90	26.37
Net lending/borrowing of the public authorities						
-Million €-current prices	1353.54	1957.03	3231.55	205.34	405.56	791.98
-% of GDP	0.37	0.43	0.58	0.06	0.09	0.14

Source: HERMES

5.5. Sensitivity analysis

5.5.1. Impact of a higher carbon value

Since there are much uncertainties about the ambition level of the international agreement and since this will influence the carbon price, a sensitivity analysis based on a carbon value of 40 €/tCO_2 for both ETS and non-ETS was carried out. For RES production, it is still assumed that Belgium domestically achieves 12.3% and the RES value is computed accordingly. The corresponding scenario is referred to in the following as the *30/20 scenario assuming higher CV*.

The following sub-sections provide an evaluation of the impact this higher carbon price has on several indicators, namely GHG emissions and RES production in Belgium and the direct cost.

a. Impact on GHG emissions and RES production

Assuming a higher international carbon price leads to a higher domestic reduction effort: total GHG emissions are reduced by 3.8% in 2020 from 2005, compared to a reduction of 1.4% in the *30/20 target scenario*. Table 25 below goes one step further in the analysis of impacts. It also shows the effect on the ETS and non-ETS sectors as well as changes with respect to the baseline in 2020.

Table 25: Impact of higher carbon prices on GHG emissions, 30/20 target scenario, year 2020 (%)

	2020 vs. 2005		2020-change from baseline	
	CV=30 €/tCO_2	CV=40 €/tCO_2	CV=30 €/tCO_2	CV=40 €/tCO_2
All GHGs	-1.4	-3.8	-12.8	-14.9
ETS sectors	+12.2	+10.3	-11.0	-12.5
Non-ETS sectors	-11.1	-14.0	-14.3	-17.1

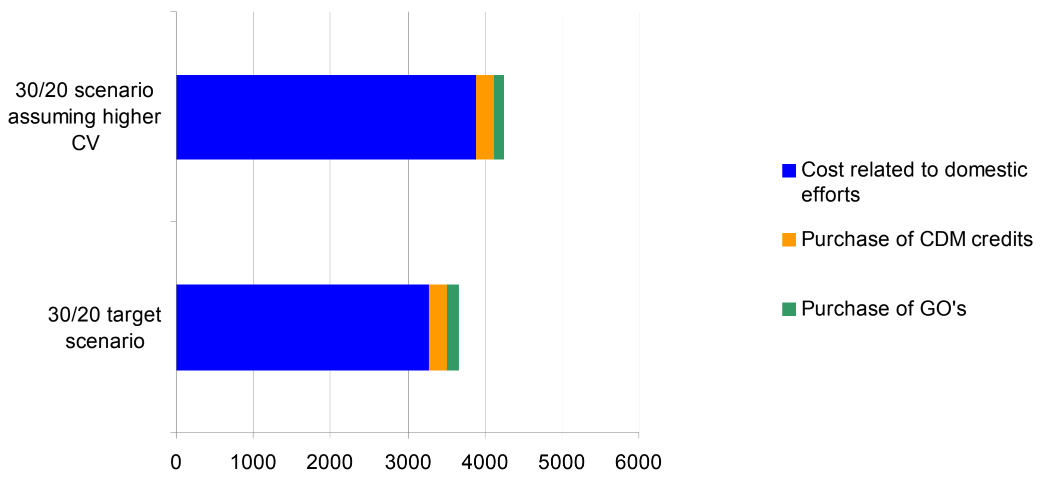
Source: PRIMES, NTUA

Moreover, as a higher carbon price brings about more energy savings, a comparatively lower RES production is required to meet the domestic RES target of 12.3%. With a carbon price of 40 €/tCO_2, the RES value is estimated to be 45 €/MWh and RES production to be 4800 ktoe in 2020, compared to 49 €/MWh and 4900 ktoe respectively in the *30/20 target scenario* where a carbon value of 30 €/tCO_2 is implemented.

b. Impact on direct cost

Disregarding the cost related to the distribution of auctioning revenues (the evaluation of which is out of the scope of the current analysis), Figure 33 shows that the major effect of a difference of 10 €/tCO_2 for the international carbon price is on the cost related to domestic effort. The gap between the two figures amounts to about 600 million € of 2005 in 2020 (or a difference of 16%).

Figure 33: Impact of a higher international carbon price on direct cost, 30/20 target scenario, year 2020 (mln € of 2005)



Source: PRIMES, NTUA

NB: Purchase of CDM credits relates only to non-ETS. The direct cost of the *30/20 target scenario* is 3.7 billion € in 2020 whereas the direct cost of the *30/20 scenario* assuming higher CV is 4.3 billion €.

On the other hand, the purchases of CDM credits and GO's are comparable in both scenarios[57]: the former ranges between 230 and 240 million €, the latter between 140 and 150 million €[58].

c. Impact on energy related costs per sector

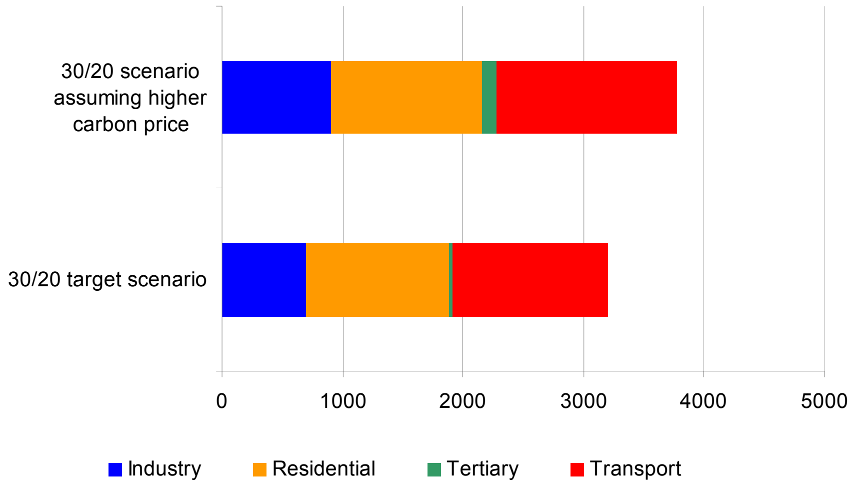
As expected, a higher carbon value in both ETS and non-ETS sectors increases the energy related costs in all sectors. However, Figure 34 shows that although the increase is remarkable in industry, transport and in the tertiary sector, it is rather limited in the residential sector. The cost dif-

57 Higher carbon prices are compensated for by a reduction in the amount of CDM credits needed to meet the -21% GHG target in the non-ETS.

58 The higher figures correspond to the *30/20 target scenario* while the lower are for the *30/20 scenario* assuming higher carbon prices.

ference of about 600 million € in 2020 between the two scenarios is allocated as follows: 38% for industry, 37% for transport, 16% for the tertiary sector and 9% for the residential sector.

Figure 34: Impact on the direct cost related to domestic effort, per sector, 30/20 target scenario, year 2020 (mln € of 2005)

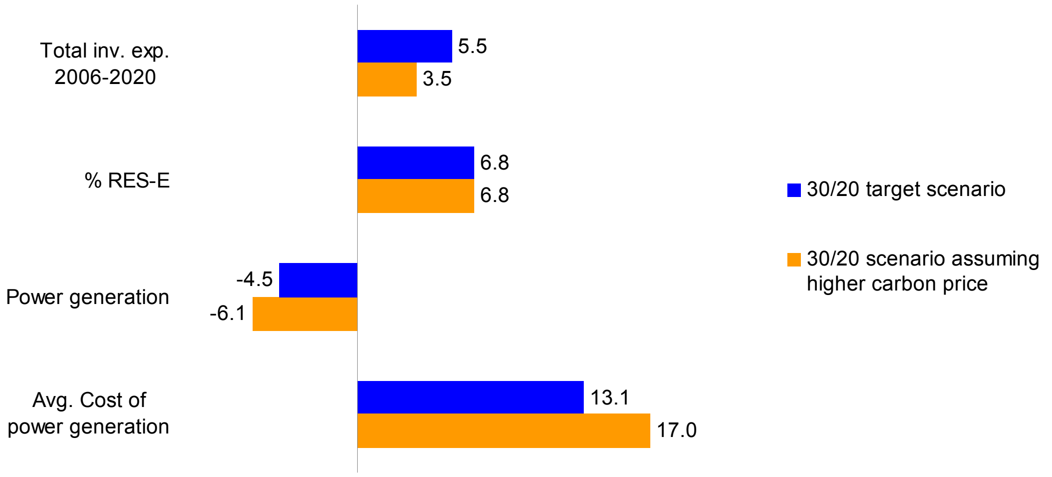


Source: PRIMES, NTUA

NB: The direct cost related to domestic effort of the *30/20 target scenario* is 3.2 billion € in 2020 while the direct cost related to domestic effort of the *30/20 scenario* assuming higher carbon price is 3.8 billion € (both figures include only energy related costs).

The following figure focuses on the impact of CDM on several cost indicators in the power generation sector.

Figure 35: Impact on several indicators of the power generation sector, 30/20 target scenario, year 2020: % change from baseline



Source: PRIMES, NTUA

In the *30/20 scenario assuming higher carbon price*, the power sector, belonging to the ETS, faces higher carbon prices but slightly lower RES value than in the *30/20 target scenario*. The net effect on the power sector is a more significant decrease in power generation compared to the baseline (-6.1% in 2020 compared to -4.5% with a CV of 30 €/tCO_2) because of the more pronounced impact on the demand for electricity and a higher increase in average cost of power generation (+17% in 2020 against +13.1% with a lower CV). The former impact implies much lower investment expenditures over 2006-2020 compared to the baseline (+3.5% in 2020 against +5.5%). Finally, regarding the share of RES for electricity production, the results are comparable.

6. Annex

6.1. International fuel prices

6.1.1. Evolution of energy prices in the baseline and target scenarios

The oil and gas prices in the baseline and in the target scenarios develop as outlined in Table 26[59]. The gas prices follow the same evolution as the oil prices; the price of coal is stable in real terms.

Table 26: Evolution of international energy prices (2005$/boe) and the price of biomass (index 2005=100)

	2005	2010	2015	2020	2025	2030	2020//2005
Evolution of international energy prices (2005$/boe)							
Oil	54.5	54.5	57.9	61.1	62.3	62.8	0.8%
Natural gas	34.6	41.5	43.4	46.0	47.2	47.6	1.9%
Coal	14.8	13.7	14.3	14.7	14.8	14.9	0.0%
Evolution of the price of biomass (index 2005 = 100)							
Power generation	100	117	128	142	153	162	2.4%
Tertiary/households	100	100	103	104	108	108	0.3%

Source: EC-DG TREN (2008).
//: average annual growth rate.

6.1.2. Impact of higher international energy prices on the realisation of the Energy/Climate Package

The evolution of oil, gas and coal prices on international or regional markets influences the development of the energy system but also the reaction of the energy system to constraints on GHG emissions and RES production as well as the cost to comply with these constraints. Alternative energy price assumptions were not studied in the framework of this study. However, the model based analysis conducted by NTUA (Capros, 2008) for the Directorate-General for Environment (DG ENV) includes a quantitative evaluation of the effect higher fossil fuel prices (see Table 27) can have on a cost-effective emission reduction and RES deployment scenario. Looking at those results gives an insight in the potential changes on the analysis presented in this report.

Table 27: 'Higher' evolution of international energy prices (2005$/boe)

	2005	2010	2015	2020	2025	2030
Oil	54.5	69.7	83.3	100.1	110.6	119.0
Natural gas	34.6	46.3	61.4	77.5	79.5	87.3
Coal	14.8	15.8	20.3	24.2	26.5	27.9

Source: Capros (2008)

59 Figures are expressed in prices of 2005; in nominal terms this could be over 100 $/barrel in 2020 if it is assumed that the inflation target of the ECB of 2% per year is reached.

The evaluation made in (Capros, 2008) cannot be applied straightforwardly to our analysis for two main reasons. First, the assumptions behind the baseline slightly differ between the two exercises (see annex 6.2); secondly, the GHG/RES target scenario in (Capros, 2008) builds upon a cost-effective allocation of the 20% reduction target for GHG emissions without recourse to CDM and of the 20% deployment objective for RES whereas our *20/20 target scenario* mimics the EC proposal for Belgium.

Nevertheless, some lessons can be learnt. A first conclusion of the model based analysis of (Capros, 2008) is that higher fossil fuel prices induce a lower effort to meet the two targets (GHG and RES): the carbon and RES values are lower compared to those required in the analysis with moderate prices (respectively 12% and 18% lower). Consequently, the direct cost related to domestic effort is also lower: 2.2 billion € in 2020 compared to 3.1 billion € in a scenario where the targets are allocated according to the same principles (i.e. cost-efficiency and entirely within the EU) but in which energy prices are those of Table 27.

On the other hand, total energy system costs increase substantially in the high price baseline scenario: 52 billion € in 2020, compared to 32 billion € in 2005 and to 44 billion € in 2020 in our baseline scenario. In other words, the impact of higher fossil fuel prices on total energy system costs is much larger than the cost for meeting the two targets.

Another interesting result concerns the impact on GHG emissions and RES production. With higher international energy prices, the cost-efficient allocation of the 20% GHG reduction target at EU level leads to a slightly larger decrease in Belgian GHG emissions between 2005 and 2020: -11% compared to -9% in a scenario where the target is allocated according to the same principles (i.e. cost-efficiency and entirely within the EU) but where energy prices are lower. On the contrary, the cost-efficient allocation of the 20% RES target at EU level leads to a slightly higher percentage of RES in Gross Final Energy Demand: 13.3% compared to 12.9% in a scenario where the target is allocated according to the same principles (i.e. cost-efficiency) but where energy prices are lower.

6.2. Differences between the DG TREN 2008 baseline and the FPB baseline used in this study

The baseline scenario used in this study is the GAINS baseline for non-CO_2 gases and the PRIMES baseline for CO_2 gases (energy as well as non-energy). The PRIMES baseline (further on called the (*FPB) baseline*) is the one that is calculated for DG TREN of the European Commission (published in April 2008), but diverges on 2 points:

1. The FPB baseline assumes a higher steel production in Belgium in the period 2010-2020 according to information obtained from the regional Environment Administrations (see Table 28);

Table 28: Steel production in DG TREN and FPB baseline, period 2005-2020

		2005	2010	2015	2020
DG TREN Baseline					
Integrated steelworks	BE	7255	6700	6712	6683
Electric Processing	BE	3163	3935	4235	4483
Physical Output (kton)	BE	10418	10634	10947	11166
FPB Baseline[1]					
Integrated steelworks	BE	7930	10470	11770	11770
Arcelor Mittal Seraing & Ougrée	WALL	1529	3170	3170	3170
Carsid	WALL	1785	2100	2100	2100
ArcelorMittal Gent	VL	4616	5200	6500	6500
Electric Processing	BE	2645	3948	4248	4248
Various installations	WALL	1780	2848	2848	2848
ArcelorMittal Genk	VL	865	1100	1400	1400
Physical Output (kton)	BE	10575	14418	16018	16018

[1] Source: Flanders and Walloon Environment Administrations

2. The option of CCS is left open. This option nevertheless only extends to one unit of 300 MW in Belgium in the year 2020[60].

All other assumptions for the FPB baseline are taken from the DG TREN, 2008 publication as can be integrally downloaded from
http://ec.europa.eu/dgs/energy_transport/figures/trends_2030_update_2007/energy_transport_trends_2030_update_2007_en.pdf.

Just to give an indication as to how results can be affected by the difference in baseline assumptions, some indicators of the two diverging baselines are shown in Table 29.

60 In none of the scenarios studied, this option was taken because the carbon values resulting from the chosen scenarios are too low for this kind of technology to become competitive on a Belgian level.

Table 29: Comparison of DG TREN and FPB baseline with respect to GHG emissions, RES share in Final Energy Demand and Direct Costs, year 2020

	2005	DG TREN-Baseline (2020)		FPB-Baseline (2020)	
	(Mton CO_2-eq)	Mton CO_2-eq	2020/2005	Mton CO_2-eq	2020/2005
Total GHG emissions (including aviation)	141.3	152.5	+7.9%	159.7	+13%
ETS-sector	55.2	61.4	+11.2%	68.6	+24.3%
Non-ETS sector	82.3	85.3	+3.7%	85.3	+3.7%
Aviation	3.8	5.8	+52.0%	5.8	+52.0%
	GWh in 2005	GWh in 2020	% in 2020	GWh in 2020	% in 2020
Total RE in Final Energy Demand	9050	36700	7.8%	36850	7.5%
Electricity	4100	13400	2.8%	13 600	2.8%
Heat	500	7000	1.5%	7 100	1.4%
Biofuels	0	7400	1.6%	7 450	1.5%
Other RE sources	4450	8900	1.9%	8 700	1.8%
Direct energy system costs (bn €)	32	43		44	

Source: EC-DG TREN (2008), NTUA

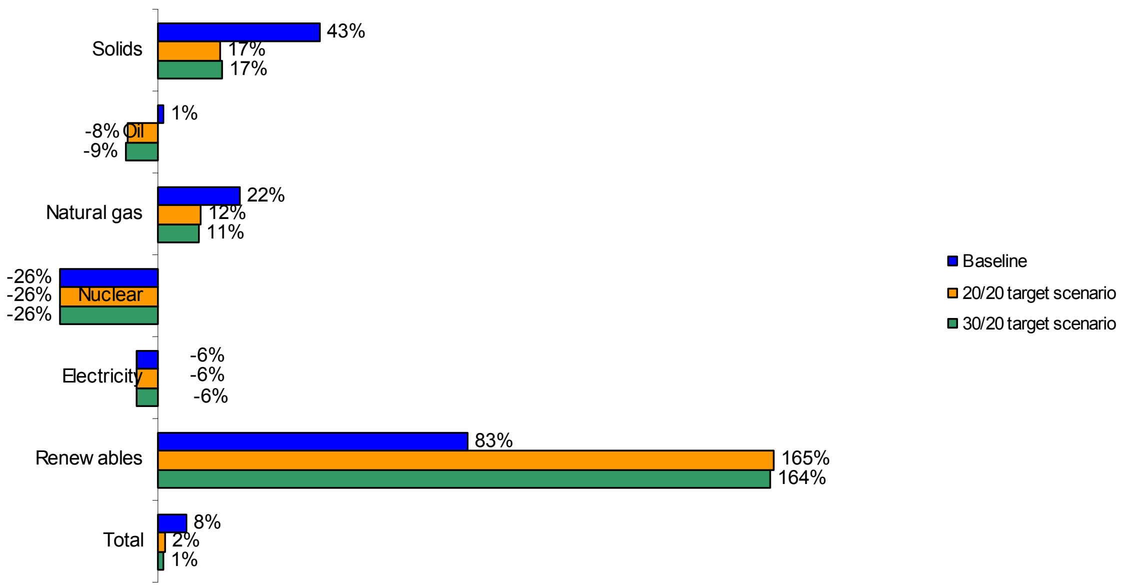
/: growth rate.

6.3. Some additional comparative figures of the three scenarios

6.3.1. Gross Inland Consumption

The graph below depicts the percentage change from the year 2005 of the Gross Inland Consumption for the three main scenarios in 2020: baseline, *20/20* and *30/20 target scenarios*.

Figure 36: Gross Inland Consumption, all scenarios, year 2020: % change from 2005

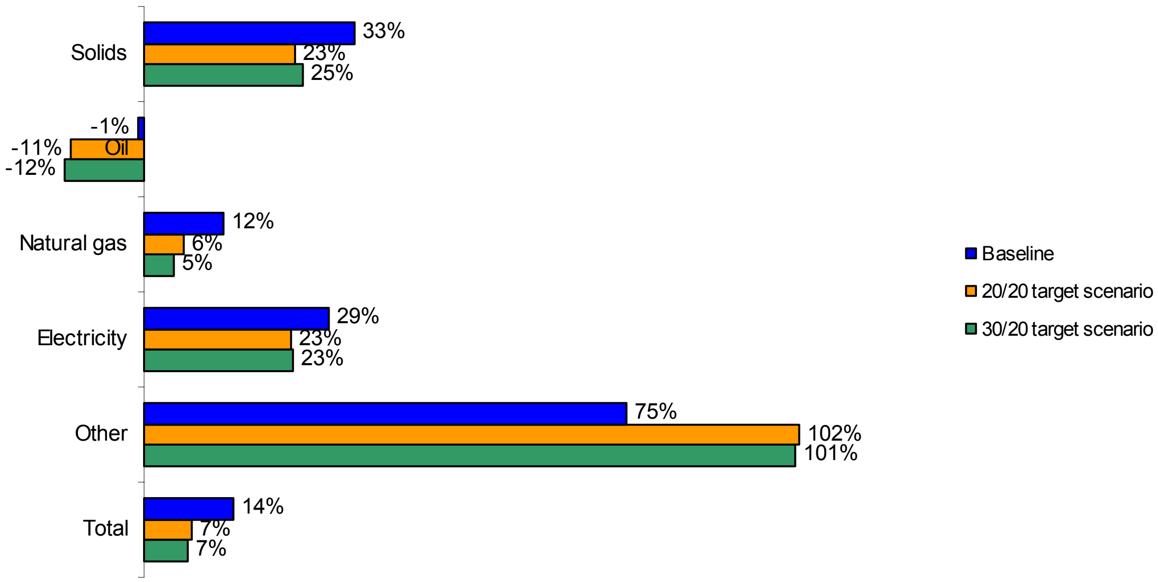


Source: PRIMES

6.3.2. Final Energy Demand

A similar approach is followed for the Final Energy Demand in Figure 37.

Figure 37: Final Energy Demand, all scenarios, year 2020: % change from 2005

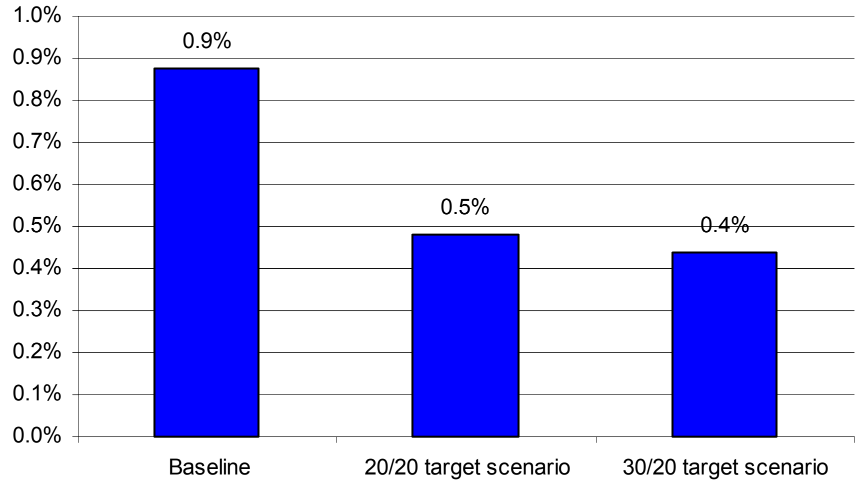


Source: PRIMES

NB: "Other" stands for renewable energy and heat.

As can be seen in both graphs, one of the consequences of establishing a CV is that the consumption of energy is reduced compared to the baseline. Not surprisingly, the reduction scenarios (with non-ETS CV's of 25 and 30 €/tCO_2 respectively in the *20/20* and *30/20 target scenario*) then have lower FED's in the year 2020 compared to the baseline and, thus, lower average annual growth rates over the period 2005-2020. The following graph depicts this difference in average annual growth rate between the three main scenarios.

Figure 38: Average annual growth rate of Final Energy Demand, all scenarios, period 2005-2020

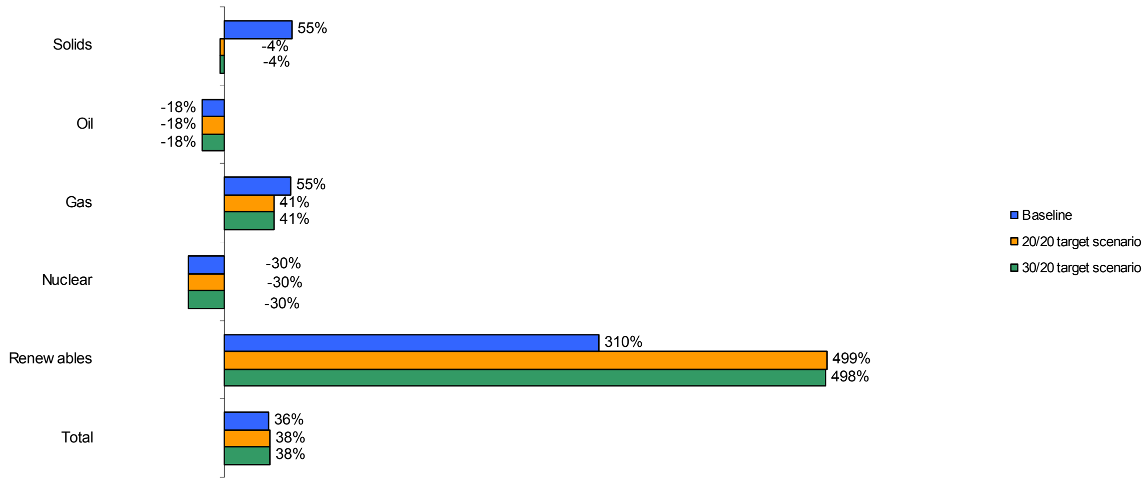


Source: PRIMES, own calculations

6.3.3. Power generation

A comparative figure for all three scenarios was also established for the additional (from 2005 onwards) net installed power capacity.

Figure 39: Net installed power capacity, all scenarios, year 2020: % change from 2005



Source: PRIMES

6.4. Detailed energy, emission and cost figures for the three scenarios

Table 30: Energy and CO_2 emissions indicators, year 2005 and 2020

		2005	2020 baseline	2020 20/20 target scenario	2020 30/20 target scenario
Gross Inland Consumption (ktoe)		54410	58649	55487	55235
	Solids	5450	7815	6359	6386
	Oil	20547	20819	18930	18785
	Natural gas	14113	17241	15770	15657
	Nuclear	12277	9068	9068	9068
	RES	2022	3706	5360	5339
Final Energy Demand (ktoe)		36321	41386	39042	38791
by sector	Industry	11523	13705	13326	13352
	Residential	9914	10442	9765	9608
	Tertiary	5005	5708	5112	5041
	Transport	9880	11532	10839	10790
by fuel	Solids	2052	2723	2533	2559
	Oil	16443	16289	14569	14424
	Gas	9003	10116	9563	9435
	Electricity	6894	8880	8481	8490
	Heat	1548	1987	1907	1908
	Other	382	1392	1989	1976
Net electricity generation (GWh)		82064	106584	101692	101784
	Nuclear	44935	33793	33793	33793
	RES	3883	13169	19503	19465
	Solids	8282	16311	10254	10299
	Oil	1824	1001	726	741
	Natural gas	20763	39577	34652	34722
	Derived gases	2378	2733	2764	2763
Net installed power capacity (MW)		15058	20598	20796	20807
	Nuclear	5843	4096	4096	4096
	RES	822	3976	5905	5897
	Solids	1392	2162	1334	1340
	Oil	641	523	523	523
	Gas	6360	9841	8937	8952
Energy related CO_2 emissions (Mt)		107.8	121.9	106.9	106.3
	Energy sector	27.4	36.3	28.6	28.6
	Industry	20.4	23.6	23.3	23.3
	Residential	20.3	19.0	15.9	15.4
	Tertiary	10.5	10.6	9.5	9.4
	Transport	29.4	32.4	29.6	29.5

Source: PRIMES

Table 31: Energy related cost, per sector and scenario, year 2005 and 2020 (in mln € of 2005)

		2005	2020 baseline	2020 20/20 target scenario	2020 30/20 target scenario
Industry		6497	9564	10322	10256
	Energy equipment	1686	2141	2164	2164
	Fuel purchase	4812	7423	8158	8092
Residential		11697	17012	17967	18206
	Energy equipment	3464	6645	6408	6603
	Fuel purchase	8232	10362	10868	10765
	Disutility cost	0	5	690	837
Tertiary		4071	5420	5423	5446
	Energy equipment	645	1024	986	980
	Fuel purchase	3425	4394	4136	4105
	Disutility cost	0	1	300	361
Transport		9257	11779	12956	13068
	Fuel purchase	9257	11779	12574	12622
	Disutility cost	0	0	382	446
All sectors		31522	43769	45296	45331
	Energy equipment	5795	9811	9559	9747
	Fuel purchase	25727	33958	35737	35584
	Disutility cost	0	6	1373	1644

Source: PRIMES, NTUA

6.5. Cost related to domestic effort: sectoral figures

6.5.1. Average cost of power generation

Table 32: Evolution of average cost of power generation (€$_{2005}$/MWh)

	2005	2020	% change between 2005 and 2020	% change from baseline in 2020
Baseline	45.5	53.6	18.0	
20/20 target scenario	45.5	61.4	35.2	14.6
30/20 target scenario	45.5	60.7	33.5	13.1

Source: PRIMES

The cost of power generation accounts for the complementary capacity[61] required by the increase in power generation capacity based on intermittent renewable sources (wind, solar PV). In both target scenarios, the cost increases are due to the increased share of RES in the power generation system and to the impact of the carbon price on the cost of fossil fuel based power plants.

6.5.2. Energy related costs in final demand sectors

This section deals with the evolution of energy related costs in industry, the tertiary and residential sectors. Three cost indicators are described: (1) the energy cost per toe consumed, (2) the annual energy related expenses and (3) the total annual energy related cost. The difference between the second and third indicator is the disutility cost. For the residential sector, a fourth indicator is provided: the energy related expenses per household.

Energy related expenses, consisting of payments to buy energy commodities (i.e. equipment and fuel), increase less relative to the baseline than the energy cost per toe consumed because of energy savings. The energy related cost includes the payment of electricity and steam.

Table 33: Evolution of energy related cost in industry

	2005	2020	% change between 2005 and 2020	% change from baseline in 2020
Energy cost per toe consumed (€'05/toe)				
Baseline	573	707	23.4	
20/20 target scenario	573	785	37.0	11.0
30/20 target scenario	573	779	35.9	10.1
Annual energy related expenses (mln €'05) = total annual energy related cost				
Baseline	6497	9564	47.2	
20/20 target scenario	6497	10322	58.9	7.9
30/20 target scenario	6497	10256	57.9	7.2

Source: PRIMES, NTUA

61 Complementary capacity results from the balance between supply and demand of electricity on a yearly basis.

Table 34: Evolution of energy related cost in the tertiary sector

	2005	2020	% change between 2005 and 2020	% change from baseline in 2020
Energy cost per toe consumed (€'05/toe)				
Baseline	813	949	16.7	
20/20 target scenario	813	1002	23.2	5.6
30/20 target scenario	813	1009	24.0	6.3
Annual energy related expenses (mln €'05)				
Baseline	4071	5418	33.1	
20/20 target scenario	4071	5123	25.8	-5.5
30/20 target scenario	4071	5085	24.9	-6.2
Total annual energy related cost (mln €'05)				
Baseline	4071	5420	33.1	
20/20 target scenario	4071	5423	33.2	0.1
30/20 target scenario	4071	5446	33.8	0.5

Source: PRIMES, NTUA

Table 35: Evolution of energy related cost in the residential sector

	2005	2020	% change between 2005 and 2020	% change from baseline in 2020
Energy costs per toe consumed (€'05/toe)				
Baseline	573	707	23.4	
20/20 target scenario	573	785	37.0	11.0
30/20 target scenario	573	779	35.9	10.1
Annual energy related expenses per household (€'05)				
Baseline	2631	3405	29.4	
20/20 target scenario	2631	3459	31.4	1.6
30/20 target scenario	2631	3477	32.1	2.1
Annual energy related expenses (mln €'05)				
Baseline	11697	17007	45.4	
20/20 target scenario	11697	17277	47.7	1.6
30/20 target scenario	11697	17369	48.5	2.1
Total annual energy related cost (mln €'05)				
Baseline	11697	17012	45.4	
20/20 target scenario	11697	17967	53.6	5.6
30/20 target scenario	11697	18206	55.7	7.0

Source: PRIMES, NTUA

6.5.3. Cost and other indicators for industrial subsectors

Figures for industry are average figures for industry as a whole. The table below shows, for the *20/20 target scenario*, the changes of several indicators relative to the baseline for individual industrial subsectors.

Table 36: Changes for industrial subsectors, year 2020 (% change from baseline)

	I&S	NFM	Chem.	NMM	P&P	FDT	Eng.	Tex.	Other	Industry
Energy intensity										
value added related	-2.4	-2.3	-2.4	-2.6	-3.3	-3.2	-5.6	-4.6	-3.7	-2.8
Carbon intensity										
energy cons. related	-0.4	2.0	12.8	-0.9	-9.5	-2.0	4.2	-2.3	-0.7	1.2
value added related	-2.8	-0.3	10.1	-3.5	-12.5	-5.1	-1.7	-6.7	-4.4	-1.6
CO_2 emissions	-2.8	-0.3	10.1	-3.5	-12.5	-5.1	-1.7	-6.7	-4.4	-1.6
Energy related costs	9.4	5.3	5.5	5.0	13.8	14.4	8.3	10.5	11.3	8.0
energy related costs per toe	12.1	7.8	8.0	7.8	17.7	18.2	14.8	15.8	15.5	11.0
Final Energy Demand	-2.4	-2.3	-2.4	-2.6	-3.3	-3.2	-5.6	-4.6	-3.7	-2.8
Total unit cost of production	2.7	1.7	2.2	1.4	0.7	0.2	0.0	0.2	0.3	-

Source: PRIMES, own calculations

I&S: iron and steel; NFM: non ferrous metals; Chem: chemicals; NMM: non metallic minerals; P&P: pulp and paper; FDT: food, drink and tobacco; Eng: Engineering; Tex: textile; Other: other industries.

6.6. Macroeconomic results of HERMES variants

6.6.1. Impact of alternative recycling policies for 20/20 target scenario

The macroeconomic effects of two other recycling options were evaluated in the framework of the *20/20 target scenario* (see Table 37). In the first one, which is referred to as *mixed recycling policy*, the ETS auctioning revenues are reinvested in sectors of buildings and infrastructure, and only the non-ETS contribution is used to reduce social contributions of employers. So the same amount of public revenues is recycled in the economy as in the *full recycling policy*, but two channels are now considered. Clearly, less employment is generated in the *mixed recycling policy* compared to baseline (+20770 in 2020) as less revenue is dedicated to directly stimulate new jobs. In terms of economic growth, the impact of this simulation is however comparable to the one obtained with the *full recycling policy*, and GDP again falls only by 0.07% in 2020. Actually, two opposite demand effects are neutralized. On the one hand, domestic demand is less depressed in the *mixed recycling policy* as firms benefit from the boosting in housing investments, even if household consumption falls due to lower employment and higher inflation. On the other hand, external demand is negatively affected by the present policy, and imports suffer slightly less here (-0.49%) than by conducting the *full recycling policy* as domestic demand is less depressed. Besides, simulation results suggest that the impacts on production and on energy demand are very comparable when a same amount of public revenues is recycled in the economy using one or two channels.

The second recycling policy only carries out the redistribution of auctioning ETS revenues into housing investments to reduce GHG emissions, and is therefore called the *partial recycling policy*. Unsurprisingly, demand components are more negatively affected by this policy which is closest to the no recycling case. The impact is negative on investment as the positive effects of the public reinvestment in buildings and infrastructure only partially compensate the negative effects of the rising in energy prices (and hence firm costs). Also employment is now reduced by the implementation of the *partial recycling policy* (-12010 jobs in 2020), and real GDP loses 0.33% with respect to the baseline. This policy is however less depressive for the economy than the *no recycling policy*.

Table 37: Macroeconomic results, 20/20 target scenario, mixed recycling policy versus partial recycling policy

Differences in % wrt the baseline	Mixed recycling of public receipts			Partial recycling of public receipts		
	2010	2015	2020	2010	2015	2020
MAIN MACROECONOMIC RESULTS						
Total production	-0.04	-0.1	-0.28	-0.15	-0.43	-0.67
Energy (Final expenditures, in 2000 prices)	-0.89	-1.87	-2.88	-0.91	-1.97	-3.05
Demand components (volumes)						
Households consumption	0.03	0	-0.2	-0.1	-0.43	-0.87
Investments	-0.13	0.19	0.22	-0.15	-0.03	-0.28
of which Firms	-0.18	-0.41	-0.34	-0.21	-0.63	-0.87
Total domestic demand	-0.02	0.04	-0.06	-0.1	-0.24	-0.54
Exports of goods and services	-0.08	-0.24	-0.49	-0.1	-0.32	-0.57
Imports of goods and services	-0.12	-0.24	-0.49	-0.12	-0.34	-0.68
GDP	0.02	0.03	-0.07	-0.07	-0.2	-0.33
Deflator of private consumption	0.44	0.57	0.76	0.56	0.92	1.05
Health index	0.33	0.44	0.63	0.45	0.81	0.94
Total employment						
. in thousands	5.32	16.1	20.77	-1.29	-4.96	-12.01
. in %	0.12	0.35	0.45	-0.03	-0.11	-0.26
Productivity per head (market branches)	-0.12	-0.4	-0.61	-0.04	-0.1	-0.06
Unit labour cost (Market branches)	-0.79	-0.47	-0.26	0.39	0.85	0.92
Real disposable income	-0.28	-0.3	-0.48	-0.39	-0.66	-1.05
Gross operating surplus of firms (ratio)	0.61	0.03	-0.17	-0.18	-0.72	-0.97
MAIN SECTORAL RESULTS						
PRODUCTION (volumes)						
Agriculture	-0.07	-0.61	-0.93	-0.31	-1.19	-1.54
Energy	-0.77	-1.88	-2.77	-0.81	-2.08	-3.08
Manufacturing industries	0	-0.13	-0.21	-0.19	-0.59	-0.69
. Intermediary goods	-0.05	-0.27	-0.35	-0.24	-0.75	-0.84
. Equipment goods	0.03	0.02	0.03	-0.12	-0.32	-0.3
. Consumption goods	0.03	-0.09	-0.24	-0.19	-0.63	-0.8
Construction	-0.06	0.55	0.5	-0.11	0.24	-0.02
Transports and communication	0.12	0.14	0.01	0	-0.18	-0.4
. Transport by rail	0.08	0.13	0.06	0.02	-0.05	-0.18
. Road transport	-0.01	-0.11	-0.32	-0.13	-0.43	-0.71
. Water and air transport	-0.01	-0.19	-0.54	-0.15	-0.58	-10.2
. Other transports and communication	0.18	0.28	0.20	0.07	-0.05	-0.22
Trade, hotels, restaurants, ...	0.08	0.09	-0.11	-0.04	-0.26	-0.54
Credit, insurances	-0.07	-0.08	-0.58	-0.22	-0.59	-1.25
Health	0.01	-0.01	-0.1	0	-0.04	-0.09
Other market services	0.01	0.02	-0.13	-0.07	-0.28	-0.53
Total market branches	-0.03	-0.09	-0.26	-0.15	-0.44	-0.69
EMPLOYMENT						
Agriculture	0.01	0	-0.04	0	-0.05	-0.15
Energy	-0.2	-0.22	-0.43	-0.22	-0.4	-0.75
Manufacturing industries	0.04	0.45	0.6	-0.01	-0.06	-0.24
. Intermediary goods	0.01	0.08	-0.02	-0.01	-0.13	-0.38
. Equipment goods	0.04	0.5	1.02	-0.03	-0.07	-0.03
. Consumption goods	0.07	0.75	0.92	0	0	-0.24
Construction	0.45	1.07	1.13	-0.12	0.16	-0.11

Differences in % wrt the baseline	Mixed recycling of public receipts			Partial recycling of public receipts		
	2010	2015	2020	2010	2015	2020
Transports and communication	0.24	0.48	0.52	0.03	-0.02	-0.11
. Transport by rail	0.22	0.51	0.55	-0.05	-0.28	-0.47
. Road transport	0.41	0.80	0.87	0.11	0.10	0.00
. Water and air transport	0.28	0.65	0.90	0.04	-0.12	-0.41
. Other transports and communication	0.16	0.29	0.30	0.01	-0.02	-0.07
Trade, hotels, restaurants, ...	0.06	0.17	0.23	-0.01	-0.16	-0.38
Credit, insurances	0.04	0.1	0.13	-0.02	-0.07	-0.15
Health	0.12	0.18	0.23	-0.03	-0.06	-0.09
Other market services	0.2	0.64	0.86	-0.08	-0.31	-0.56
Total market branches	0.14	0.42	0.54	-0.04	-0.13	-0.32
OTHER MACROECONOMIC RESULTS						
Current external balance (% of GDP)	0.02	0.06	0.09	0.09	0.23	0.38
Total employment (in thousands)	5.32	16.1	20.77	-1.29	-4.96	-12.01
Net lending/borrowing of the public authorities						
. million €-current prices	205.96	667.82	890.26	1357.95	1939.35	2460.33
. % of GDP	0.06	0.14	0.15	0.37	0.42	0.44

Source: HERMES

Table 38: Macroeconomic results, 20/20 scenario without CDM, no recycling policy versus full recycling policy

Differences in % wrt the baseline	No recycling of public receipts			Full recycling of public receipts		
	2010	2015	2020	2010	2015	2020
MAIN MACROECONOMIC RESULTS						
Total production	-0.15	-0.6	-0.95	-0.04	-0.13	-0.27
Energy (Final expenditures, in 2000 prices)	-0.91	-2.31	-3.82	-0.89	-2.17	-3.54
Demand components (volumes)						
Households consumption	-0.1	-0.56	-1.18	0.03	0.08	-0.01
Investments	-0.15	-0.92	-1.44	-0.13	-0.63	-0.65
of which Firms	-0.21	-1.32	-1.94	-0.18	-1.02	-1.13
Total domestic demand	-0.1	-0.52	-0.97	-0.02	-0.1	-0.16
Exports of goods and services	-0.1	-0.36	-0.64	-0.08	-0.24	-0.51
Imports of goods and services	-0.12	-0.48	-0.91	-0.12	-0.34	-0.59
GDP	-0.07	-0.34	-0.53	0.02	0.01	-0.05
Deflator of private consumption	0.56	1.07	1.33	0.44	0.56	0.8
Health index	0.45	0.92	1.14	0.33	0.39	0.6
Total employment						
. in thousands	-1.29	-8.9	-19.48	5.32	20.78	32.81
. in %	-0.03	-0.2	-0.42	0.12	0.46	0.71
Productivity per head (market branches)	-0.04	-0.14	-0.09	-0.12	-0.54	-0.9
Unit labour cost (Market branches)	0.39	0.98	1.11	-0.79	-1.12	-0.97
Real disposable income	-0.39	-0.86	-1.48	-0.28	-0.27	-0.39
Gross operating surplus of firms (ratio)	-0.18	-0.87	-1.28	0.61	0.33	0.09
MAIN SECTORAL RESULTS						
PRODUCTION (volumes)						
Agriculture	-0.31	-1.4	-1.89	-0.07	-0.52	-0.8
Energy	-0.81	-2.47	-3.95	-0.77	-2.18	-3.44
Manufacturing industries	-0.19	-0.74	-0.88	0	-0.04	-0.06
. Intermediary goods	-0.24	-0.89	-1.04	-0.05	-0.18	-0.19
. Equipment goods	-0.12	-0.46	-0.47	0.03	0.06	0.1
. Consumption goods	-0.19	-0.77	-1.02	0.03	0.04	-0.03
Construction	-0.11	-0.57	-1.02	-0.06	-0.14	-0.16
Transports and communication	0	-0.31	-0.61	0.12	0.17	0.1
. Transport by rail	0.02	-0.16	-0.33	0.08	0.11	0.07
. Road transport	-0.13	-0.59	-0.95	-0.01	-0.10	-0.29
. Water and air transport	-0.15	-0.75	-1.35	-0.01	-0.18	-0.53
. Other transports and communication	0.07	-0.16	-0.41	0.18	0.32	0.32
Trade, hotels, restaurants, ...	-0.04	-0.37	-0.71	0.08	0.15	0.03
Credit, insurances	-0.22	-0.67	-1.4	-0.07	0.09	-0.23
Health	0	-0.04	-0.09	0.01	0	-0.08
Other market services	-0.07	-0.42	-0.77	0.01	0.01	-0.08
Total market branches	-0.15	-0.63	-0.98	-0.03	-0.11	-0.24
EMPLOYMENT						
Agriculture	0	-0.06	-0.18	0.01	0.01	-0.01
Energy	-0.22	-0.5	-1.01	-0.2	-0.27	-0.54
Manufacturing industries	-0.01	-0.1	-0.34	0.04	0.57	0.96
. Intermediary goods	-0.01	-0.16	-0.46	0.01	0.12	0.09
. Equipment goods	-0.03	-0.14	-0.15	0.04	0.59	1.43
. Consumption goods	0	-0.03	-0.35	0.07	0.94	1.48

Differences in % wrt the baseline	No recycling of public receipts			Full recycling of public receipts		
	2010	2015	2020	2010	2015	2020
Construction	-0.12	-0.63	-1.17	0.45	0.73	0.88
Transports and communications	0.03	-0.06	-0.19	0.24	0.67	0.84
. Transport by rail	-0.05	-0.38	-0.68	0.22	0.75	0.98
. Road transport	0.11	0.08	-0.06	0.41	1.11	1.39
. Water and air transport	0.04	-0.16	-0.54	0.28	0.91	1.51
. Other transports and communication	0.01	-0.05	-0.14	0.16	0.41	0.49
Trade, hotels, restaurants, ...	-0.01	-0.2	-0.51	0.06	0.25	0.44
Credit, insurances	-0.02	-0.08	-0.17	0.04	0.16	0.26
Health	-0.03	-0.07	-0.11	0.12	0.3	0.41
Other market services	-0.08	-0.42	-0.8	0.2	0.92	1.47
Total market branches	-0.04	-0.24	-0.51	0.14	0.55	0.85
OTHER MACROECONOMIC RESULTS						
Current external balance (% of GDP)	0.09	0.37	0.61	0.02	0.12	0.13
Total employment (in thousands)	-1.29	-8.9	-19.48	5.32	20.78	32.81
Net lending/borrowing of the public authorities						
. million €-current prices	1357.95	2612.86	3594.17	205.96	-17.49	288.93
. % of GDP	0.37	0.57	0.64	0.06	-0.01	0.04

Source: HERMES

Table 39: Macroeconomic results, 20/20 scenario without CDM, mixed recycling policy versus partial recycling policy

Differences in % wrt the baseline	Mixed recycling of public receipts			Partial recycling of public receipts		
	2010	2015	2020	2010	2015	2020
MAIN MACROECONOMIC RESULTS						
Total production	-0.04	-0.09	-0.29	-0.15	-0.48	-0.81
Energy (Final expenditures, in 2000 prices)	-0.89	-2.16	-3.54	-0.91	-2.27	-3.76
Demand components (volumes)						
Households consumption	0.03	0.02	-0.19	-0.1	-0.49	-1.05
Investments	-0.13	0.23	0.23	-0.15	-0.02	-0.38
of which Firms	-0.18	-0.44	-0.41	-0.21	-0.69	-1.05
Total domestic demand	-0.02	0.06	-0.05	-0.1	-0.27	-0.66
Exports of goods and services	-0.08	-0.26	-0.53	-0.1	-0.35	-0.64
Imports of goods and services	-0.12	-0.26	-0.54	-0.12	-0.38	-0.78
GDP	0.02	0.05	-0.05	-0.07	-0.23	-0.41
Deflator of private consumption	0.44	0.66	0.94	0.56	1.08	1.36
Health index	0.33	0.49	0.74	0.45	0.93	1.18
Total employment						
. in thousands	5.32	19.3	27.85	-1.29	-5.57	-14.71
. in %	0.12	0.42	0.6	-0.03	-0.12	-0.32
Productivity per head (market branches)	-0.12	-0.45	-0.78	-0.04	-0.11	-0.08
Unit labour cost (Market branches)	-0.79	-0.69	-0.56	0.39	0.97	1.14
Real disposable income	-0.28	-0.34	-0.58	-0.39	-0.77	-1.32
Gross operating surplus of firms (ratio)	0.61	0.14	-0.07	-0.18	-0.81	-1.18
MAIN SECTORAL RESULTS						
PRODUCTION (volumes)						
Agriculture	-0.07	-0.62	-0.98	-0.31	-1.33	-1.83
Energy	-0.77	-2.16	-3.45	-0.81	-2.4	-3.85
Manufacturing industries	0	-0.1	-0.17	-0.19	-0.67	-0.82
. Intermediary goods	-0.05	-0.25	-0.31	-0.24	-0.83	-1
. Equipment goods	0.03	0.05	0.06	-0.12	-0.37	-0.39
. Consumption goods	0.03	-0.05	-0.18	-0.19	-0.7	-0.96
Construction	-0.06	0.62	0.56	-0.11	0.27	-0.1
Transports and communication	0.12	0.17	0.03	0	-0.22	-0.52
. Transport by rail	0.08	0.17	0.10	0.02	-0.05	-0.21
. Road transport	-0.01	-0.10	-0.33	-0.13	-0.49	-0.86
. Water and air transport	-0.01	-0.20	-0.63	-0.15	-0.67	-1.27
. Other transports and communication	0.18	0.31	0.24	0.07	-0.08	-0.33
Trade, hotels, restaurants, ...	0.08	0.14	-0.05	-0.04	-0.28	-0.62
Credit, insurances	-0.07	0.04	-0.4	-0.22	-0.58	-1.29
Health	0.01	-0.01	-0.1	0	-0.03	-0.09
Other market services	0.01	0.04	-0.12	-0.07	-0.32	-0.65
Total market branches	-0.03	-0.07	-0.26	-0.15	-0.49	-0.83
EMPLOYMENT						
Agriculture	0.01	0.01	-0.03	0	-0.06	-0.17
Energy	-0.2	-0.27	-0.58	-0.22	-0.48	-0.97
Manufacturing industries	0.04	0.51	0.76	-0.01	-0.08	-0.31
. Intermediary goods	0.01	0.1	0.02	-0.01	-0.14	-0.44
. Equipment goods	0.04	0.55	1.23	-0.03	-0.09	-0.09
. Consumption goods	0.07	0.85	1.17	0	-0.01	-0.31
Construction	0.45	1.28	1.45	-0.12	0.18	-0.21

Differences in % wrt the baseline	Mixed recycling of public receipts			Partial recycling of public receipts		
	2010	2015	2020	2010	2015	2020
Transports and communication	0.24	0.58	0.7	0.03	-0.02	-0.14
. Transport by rail	0.22	0.62	0.76	-0.05	-0.32	-0.59
. Road transport	0.41	0.97	1.18	0.11	0.13	0.01
. Water and air transport	0.28	0.77	1.21	0.04	-0.13	-0.48
. Other transports and communication	0.16	0.34	0.40	0.01	-0.03	-0.10
Trade, hotels, restaurants, ...	0.06	0.21	0.33	-0.01	-0.18	-0.45
Credit, insurances	0.04	0.13	0.19	-0.02	-0.08	-0.17
Health	0.12	0.23	0.31	-0.03	-0.07	-0.11
Other market services	0.2	0.77	1.16	-0.08	-0.35	-0.68
Total market branches	0.14	0.51	0.72	-0.04	-0.15	-0.39
OTHER MACROECONOMIC RESULTS						
Current external balance (% of GDP)	0.02	0.05	0.09	0.09	0.25	0.46
Total employment (in thousands)	5.32	19.3	27.85	-1.29	-5.57	-14.71
Net lending/borrowing of the public authorities						
. million €-current prices	205.96	676.52	989.41	1357.95	2308.77	3198.92
. % of GDP	0.06	0.14	0.17	0.37	0.5	0.57

Source: HERMES

6.6.2. Impact of alternative recycling policies for 30/20 target scenario

The macroeconomic effects of two other recycling options were also evaluated in the framework of the *30/20 target scenario* (see Table 40). The impact is first outlined for the *mixed recycling policy*, which redistributes the ETS auctioning revenues in investments specific to the sectors of buildings and infrastructure, and only uses CO_2 taxes paid by the non-ETS sector to reduce social contributions of employers.

The policy has a positive effect on employment and 22620 new jobs are created with respect to the baseline in 2020. However, as less public revenues are redistributed to stimulate employment, figures are lower in the *mixed recycling policy* than using *the full recycling policy*. Despite the rising in energy prices, the impact on GDP is quite limited (-0.05%) and is lower than the one obtained in section 3.1.4 (-0.12%). It turns out that domestic demand is now much stimulated by the *mixed recycling policy* in 2020 (+0.08%) as firms take advantage of the more important boosting in housing investments. The positive effects on investment dominate the drop in consumption due to lower employment and higher inflation. On the other hand, exports are depressed by the *mixed recycling policy* while the cut in imports is less pronounced than with the *full recycling policy* (domestic demand effect). Besides, the impacts on production and on energy demand reveal to be negative but, if all revenues had been recycled in employers' contributions' reductions, these impacts would have been a bit more negative. So the use of two redistribution channels instead of one limits the negative effects on the economy in the *30/20 target scenario*, though less employment is generated.

In the second recycling policy, the *partial recycling policy*, only the auctioning rights coming from the ETS sector are reinvested into specific investments in order to reduce GHG emissions. Unsurprisingly, demand components are more negatively affected by this policy (the effects on investment, though positive, do not compensate the deterioration of other components of GDP due to the shock in the energy prices). In 2020, employment is now reduced by 11370 units with respect to the baseline, and economic growth loses 0.33%. The *partial recycling policy* is however less depressive for the economy than the *no recycling policy*.

Table 40: Macroeconomic results, 30/20 target scenario, mixed recycling policy versus partial recycling policy

Differences in % wrt the baseline	Mixed recycling of public receipts			Partial recycling of public receipts		
	2010	2015	2020	2010	2015	2020
MAIN MACROECONOMIC RESULTS						
Total production	-0.04	-0.09	-0.27	-0.15	-0.42	-0.69
Energy (Final expenditures, in 2000 prices)	-0.89	-1.94	-3.04	-0.91	-2.04	-3.21
Demand components (volumes)						
Households consumption	0.03	-0.01	-0.17	-0.1	-0.44	-0.86
Investments	-0.13	-0.03	0.77	-0.15	-0.25	0.26
of which Firms	-0.18	-0.52	-0.01	-0.21	-0.75	-0.54
Total domestic demand	-0.02	-0.01	0.08	-0.1	-0.3	-0.41
Exports of goods and services	-0.08	-0.24	-0.51	-0.1	-0.32	-0.59
Imports of goods and services	-0.12	-0.28	-0.43	-0.12	-0.38	-0.62
GDP	0.02	0.02	-0.05	-0.07	-0.21	-0.33
Deflator of private consumption	0.44	0.6	0.86	0.56	0.96	1.17
Health index	0.33	0.46	0.7	0.45	0.83	1.03
Total employment						
. in thousands	5.3	15.5	22.62	-1.29	-5.76	-11.37
. in %	0.12	0.34	0.49	-0.03	-0.13	-0.25
Productivity per head (market branches)	-0.12	-0.38	-0.64	-0.04	-0.08	-0.07
Unit labour cost (Market branches)	-0.79	-0.49	-0.24	0.38	0.84	1.02
Real disposable income	-0.28	-0.3	-0.47	-0.38	-0.67	-1.06
Gross operating surplus of firms (ratio)	0.61	0.09	-0.39	-0.18	-0.67	-1.23
MAIN SECTORAL RESULTS						
PRODUCTION (volumes)						
Agriculture	-0.07	-0.5	-1.03	-0.31	-1.09	-1.68
Energy	-0.77	-1.95	-2.98	-0.8	-2.15	-3.3
Manufacturing industries	0	-0.03	-0.34	-0.19	-0.5	-0.85
. Intermediary goods	-0.05	-0.1	-0.55	-0.24	-0.58	-1.08
. Equipment goods	0.03	0.03	0.01	-0.12	-0.32	-0.34
. Consumption goods	0.03	0	-0.37	-0.19	-0.55	-0.97
Construction	-0.06	0.32	1.01	-0.11	0	0.47
Transports and communication	0.12	0.16	0	0	-0.17	-0.43
. Transport by rail	0.08	0.13	0.09	0.01	-0.05	-0.16
. Road transport	-0.01	-0.08	-0.35	-0.13	-0.41	-0.76
. Water and air transport	-0.01	-0.18	-0.61	-0.15	-0.58	-1.11
. Other transports and communication	0.18	0.29	0.20	0.07	-0.04	-0.25
Trade, hotels, restaurants, ...	0.08	0.1	-0.08	-0.04	-0.25	-0.53
Credit, insurances	-0.07	-0.06	-0.45	-0.22	-0.58	-1.15
Health	0.01	-0.01	-0.09	0	-0.03	-0.08
Other market services	0.01	0.02	-0.11	-0.07	-0.29	-0.53
Total market branches	-0.03	-0.07	-0.26	-0.15	-0.43	-0.71
EMPLOYMENT						
Agriculture	0.01	0.01	-0.04	0	-0.05	-0.15
Energy	-0.2	-0.26	-0.55	-0.22	-0.44	-0.87
Manufacturing industries	0.04	0.46	0.57	-0.01	-0.06	-0.29
. Intermediary goods	0.01	0.11	-0.03	-0.01	-0.1	-0.4
. Equipment goods	0.04	0.5	1.03	-0.03	-0.07	-0.05
. Consumption goods	0.07	0.75	0.86	0	-0.01	-0.34
Construction	0.44	0.82	1.63	-0.12	-0.1	0.33

Differences in % wrt the baseline	Mixed recycling of public receipts			Partial recycling of public receipts		
	2010	2015	2020	2010	2015	2020
Transports and communication	0.24	0.48	0.53	0.03	-0.03	-0.12
. Transport by rail	0.20	0.49	0.55	-0.07	-0.32	-0.50
. Road transport	0.41	0.80	0.90	0.11	0.10	-0.01
. Water and air transport	0.27	0.66	0.93	0.04	-0.12	-0.43
. Other transports and communication	0.16	0.29	0.31	0.01	-0.02	-0.08
Trade, hotels, restaurants, ...	0.06	0.17	0.24	-0.01	-0.17	-0.39
Credit, insurances	0.04	0.1	0.14	-0.02	-0.07	-0.15
Health	0.12	0.18	0.23	-0.03	-0.07	-0.1
Other market services	0.2	0.64	0.89	-0.08	-0.32	-0.57
Total market branches	0.14	0.41	0.58	-0.04	-0.16	-0.3
OTHER MACROECONOMIC RESULTS						
Current external balance (% of GDP)	0.02	0.07	0.03	0.09	0.24	0.33
Total employment (in thousands)	5.3	15.5	22.62	-1.29	-5.76	-11.37
Net lending/borrowing of the public authorities						
. million €-current prices	205.34	498.37	974.98	1353.54	1781.75	2634.66
. % of GDP	0.06	0.11	0.16	0.37	0.39	0.47

Source: HERMES

6.7. Short description of PRIMES, GAINS and HERMES

6.7.1. The PRIMES model

The model PRIMES generates long term (horizon up to 2030) energy and emissions' projections on the supranational (European) and national (e.g. Belgian) level. For a number of years, European Commission's DG TREN makes use of the PRIMES model in order to elaborate energy projections for the EU as a whole, next to individual nation's projections. The PRIMES model is being developed and managed in the University of Athens (NTUA) by a team under the coordination of Prof. P. Capros. For some of the hypotheses, the NTUA makes use of the output of other universities or scientific institutions, like for example international energy prices (on the basis of POLES, supplemented by the world energy model PROMETHEUS and revised by a number of experts) and the modelling of the transport activity (on the basis of SCENES, a European transport network model).

PRIMES is a modelling system that simulates a market equilibrium solution for energy supply and demand in the European Union (EU) Member States. The model determines the equilibrium by finding the prices of each energy form such that the quantity producers find best to supply matches the quantity consumers wish to use. The equilibrium is static (within each time period) but repeated in a time-forward path, under dynamic relationships. PRIMES can be run with perfect foresight; the model is behavioural but also represents in an explicit and detailed way the available energy demand and supply technologies and pollution abatement technologies. The system reflects considerations about market economics, industry structure, energy/environmental policies and regulation. These are conceived so as to influence market behaviour of energy system agents. The modular structure of PRIMES reflects a distribution of decision making among agents that decide individually about their supply, demand, combined supply and demand, and prices. Then the market integrating part of PRIMES simulates market clearing. PRIMES is a general purpose model. It is conceived for forecasting, scenario construction and policy impact analysis. It covers a medium to long-term horizon. It is modular and allows either for a unified model use or for partial use of modules to support specific energy studies. A more elaborate description of the PRIMES model can be found in *"The PRIMES Energy System Model, Summary Description"* by NTUA[62].

62 Downloadable via http://www.e3mlab.ntua.gr/.

6.7.2. The GAINS model

GAINS (Greenhouse gas and Air pollution Interactions and Synergies) is a model developed and managed by IIASA[63]. It explores cost-effective strategies to reduce emissions of greenhouse gases and conventional air pollutants. GAINS produces emission scenarios for all major air pollutants for any exogenously supplied projection of future economic activities, abatement potential and costs as well as interactions in abatement between various pollutants.

More specifically, GAINS considers emissions of carbon dioxide (CO_2), methane (CH_4), nitrogen oxides (NO_x), nitrous oxide (N_2O), particulate matter (TSP, PM10, PM2.5 and PM1), sulphur dioxide (SO_2) and volatile organic compounds (VOC). Certain versions of the GAINS model also contain ammonia (NH_3), carbon monoxide (CO) and fluorinated greenhouse gases (F-Gases).

As far as non-CO_2 greenhouse gases are concerned (i.e. the context of the present study), GAINS considers more than 60 different measures to control CH_4, 10 measures to control N_2O and 15 measures to control different F-gases. A summary of these measures is presented in (IIASA, 2008).

The GAINS model calculates the costs for each country and each mitigation option taking into account technology and country specific circumstances. A central assumption in cost calculations is the existence of a free market for (abatement) equipment throughout Europe that is accessible to all countries at the same conditions. In other words, the capital investment of a specific technology is independent of the country. On the contrary, other parameters such as labour costs and emission factors are country specific.

Analyses with GAINS start with a baseline projection for the various pollutants based on national projections of future activity data and information collected by available international emission inventories, assuming full implementation of current legislation. Emission projections are specified in five year intervals through the year 2030.

In order to cope with GHG emission constraints, GAINS models then emission reduction possibilities through marginal abatement cost curves which are identified per type of pollutant and per Member State. The reduction cost for non-CO_2 GHG is calculated as the integral of the marginal abatement cost curves from zero up to the level of abatement required for non-CO_2 GHG under a certain effort sharing scheme. More information about the GAINS model (data, methodology, analyses, etc) can be found on the IIASA web site (see footnote 63).

63 See http://gains.iiasa.ac.at/gains/EU/index.login?logout=1

6.7.3. The HERMES model

The macroeconomic impact of the different scenarios is calculated by means of the macro-econometric HERMES MODEL[64].

HERMES is the macro-sectoral model which is used by the Federal Planning Bureau for the computation of short to medium term projections and for variant analysis. This model belongs to the class of macro-econometric models based on time series. Keynesian mechanisms play a central role in this model: in the short run, output is determined by demand. However, in the longer run, classical effects will become predominant and, for instance, trend growth is determined by structural factors such as technical progress and demography.

It must also be noted that two versions of HERMES can be used, according to the treatment of wages. In the first version of HERMES, the wages are modelled in the following way: the real gross wages are conditioned by the productivity growth and the macroeconomic unemployment rate. The branch wage cost is then derived by multiplying the gross wage by a specific employers' SSC rate for each branch. Considering the equations, important feedback effects can alter the wage development (when variants affect the job creation paths and the unemployment rate), which in turn affects the deviations of prices, employment and activity from their initial levels.

In the second version of HERMES, the wage equations take explicitly into account the wage norm, as laid down by the law of 1996 promoting employment and protecting competitiveness. Nevertheless, in HERMES, the wage norm is imposed on the gross wage (contrary to the legal practice, the wage norm being fixed at the level of the wage cost). In the scenario where the non–indexed gross wages remain unchanged, the wage reaction to policies affecting public receipts and expenses is necessarily more limited (than in the scenario of free wage formation).

It is the second version of HERMES (which takes into account the wage norm) that was used for the present study.

Note that if we start from a baseline computed in April 2007, hypotheses regarding international energy prices, evolution of electricity prices and of the structure of the electricity production park have been adapted in order to be coherent with the corresponding PRIMES hypothesis (on international fuel prices) or results (information about electricity production park and carbon values).

The calculation of the economic impact involves the analysis of the impact, amongst other parameters, on GDP and its components, costs and prices, public revenues and expenditures, external balance, employment and activity levels in different sectors.

64 See also http://www.plan.be/websites/wp0409/nl/html_books/1nl4.html

Via the NEMESIS model, a European macro-sectoral model (the version used here models the EU15), the impact of the different scenarios on the EU economy can be estimated. The output of the NEMESIS model allows for accounting for the fact that the Belgian trading partners also experience the impact of climate policy on their economy.

7. Glossary

Auctioning of EU ETS emission rights: An EU-wide greenhouse gas allowance trading scheme (EU ETS) was implemented in January 2005. For Phase I (2005-2007) and Phase II (2008-2012) of the system, no EU-wide harmonized allocation methodology has been developed to distribute allowances (or emission rights) over the installations in the EU ETS. The choice and design of allocation methodologies was left largely to the Member States. Grandfathering allowances based on historical emissions has been the main allocation methodology applied in the first two periods of the EU ETS. In January 2008, the European Commission came with a new proposed directive for the period after 2012. In this new proposed directive, a harmonized allocation methodology is suggested. In this methodology, 'auctioning should be the basic principle for allocation, as it is the simplest and generally considered to be the most economically efficient system'.

Biomass and waste: The designation 'biomass and waste' is the generic term for a set of different sources, being biogas, solid biomass and waste of all sorts (bio and non-biological waste).

CDM: CDM stands for Clean Development Mechanism. The Clean Development Mechanism, defined initially in Article 12 of the Kyoto Protocol, allows a country with an emission-reduction or emission-limitation commitment to implement an emission-reduction project in developing countries. Such projects can earn saleable certified emission reduction credits, each equivalent to one tonne of CO_2, which can be counted towards meeting Kyoto targets.

ETS: Emission Trading Scheme. Used in the context of ETS sectors, this abbreviation refers to some specific sectors. For Belgium, these are: aviation, power and heat generation (including heat production in industrial heating installations), iron and steel, non-ferrous metals, the chemical sector, non-metallic minerals, paper and pulp and process CO_2 emissions.

Non-ETS: These are the remaining sectors, their principal actors being households, the tertiary sector (including agriculture), transport and all non-CO_2 gases.

Final Energy Demand (FED): Final energy consumption covers energy supplied to the final consumer's door for all energy uses. It is calculated as the sum of final energy consumption from all sectors. These are disaggregated to cover industry, transport, households, services and agriculture. A distinction can be made between *Gross* and *Net Final Energy Demand*. Gross FED stands for the energy commodities delivered for energy purposes to final consumers, including both the consumption of electricity and heat by the energy branch for electricity and heat production and the losses of electricity and heat in distribution and transmission[65]. Net FED only takes up the energy consumption of the final energy consumers, without considering the consumption of the energy branch nor the losses. In order to calculate the RES objective as brought forward in

65 This definition is extracted from a Non-paper from the Commission on *Clarifications regarding the definition of final energy consumption* in Article 2(c) of the RES directive.

the Energy/Climate Package of the European Commission, Gross FED is put in the denominator. In the present report, the abbreviation FED refers to net final energy demand unless specifically stated otherwise.

Gross Inland Consumption: Gross Inland energy Consumption or Total Primary Energy Consumption represents the quantity of energy necessary to satisfy inland consumption of the geographical entity under consideration. It is calculated as the sum of the Gross Inland Consumption of energy from solid fuels, oil, gas, nuclear and renewable sources. When studying the evolution of Gross Inland Consumption in countries where significant changes occur in the development of nuclear energy, the results should be interpreted with caution. This applies to Belgium in particular where a nuclear phase-out was decided (the dismantling of the first nuclear power plants starts in 2015). For nuclear heat, a statistical convention has been used for many years. According to this convention, an average efficiency of 33% is attributed to nuclear power plants in order to calculate the primary energy requirements corresponding to nuclear electricity. Given that current and future fossil-fuel based power plants, as well as those using renewable energy sources, have conversion efficiencies considerably higher than 33% (e.g. about 55% for combined cycle gas turbines, 100% for wind turbines), the progressive decommissioning of nuclear plants translates into comparatively lower primary energy inputs. So a decrease in primary energy inputs (or total GIC) caused by the nuclear phase-out and the subsequent replacement by fossil fuel- and RES-based units does not necessarily reflect the degree of energy efficiency improvement of our economy. A better indicator in this respect is given by the evolution of FED.

Difference between GIC and FED: Having read these definitions, it is clear that the GIC encompasses more than FED alone. GIC is also being made up of other transformation processes, the energy branch and energy losses. On top of that, the two indicators have a different way of accounting for energy consumptions. As regards the RES objective stated in the Energy/Climate Package of January 2008, this is a ratio of renewable energy sources and Gross FED. When considering the share of RES in GIC, this is the result of a completely different calculation than the one used in the determination of the E/C RES target, and no magical formula exists to switch from one ratio to the other. That is why shares do not have to be identical, nor do they have to be relatively constant in time. It therefore comes as no surprise that in the year 2005 the share of RES in FED (2.1%) is lower than the share of RES in GIC (3.7%), whilst in 2020 in the *20/20 target scenario* the situation is reversed and RES take up a share of 12.3% in Gross FED and only 9.6% in GIC.

Renewable value (RV): The monetary value used in the PRIMES model to calculate the optimal renewable energy production under a certain imposed overall target. This value can be interpreted as a virtual subsidy and enters into calculations as a negative unit cost (or positive unit gain). Since it is a virtual subsidy, the RV does not make energy cheaper; it just influences the optimal fuel mix as considered by each economic agent. The accounting costs for electricity and heat production are still calculated on the basis of true capital costs, O&M costs, fuel costs, etc., and these calculations are used to determine consumer prices.

The mechanism of *green certificates* that exists in the Belgian Regions must be distinguished from the RV for two reasons:

- First, because the RV considers all renewable energy forms (heating and cooling, electricity and transport) whilst the green certificates only relate to electricity produced from renewable energy forms.
- Secondly, the technical mechanisms to model the RV and green certificates are completely different. Green certificates are not being modelled as such because PRIMES only models energy flows, not non-physical (market transaction) flows. To then accurately represent current policy, a subsidy on investment - declining over time and calibrated in such a way that the development of RES-E is on track with the target set for 2010 - is assigned, whilst the RV represents a virtual (non paid) subsidy and is in fact the dual variable of the renewable constraint.

As for the *green certificates*, it is also worthwhile mentioning that the system has changed since the end of 2006. For this study, the cut-off legislation date was at the end of 2006.

Steering Committee: The Steering Committee encompasses representatives of all involved (federal and regional) governments which commissioned this study (16 members in total). This group included a few persons belonging to the Cabinets of the Environment Ministers. The Steering Committee guided the study, provided it with the necessary input and acted as a think tank together with the Federal Planning Bureau. The president of this Committee was Patricia Grobben of the Flemish Government, Department Environment, Nature and Energy.

8. References

Amann et al. (2008), *Emission scenarios for non-CO_2 greenhouse gases in the EU-27 – Mitigation potentials and costs in 2020*, Final report, IIASA.

Capros et al. (2008), *Model based Analysis of the 2008 EU Policy Package on Climate Change and Renewables*, Report to the European Commission, DG ENV.

Centrale Raad voor het Bedrijfsleven (2005), *Advies over energie-efficiëntie in de woningsector in België*.

Energy Economics Group & Fraunhofer Institute Systems and Innovation Research (2008), *Futures-E, 20% RES by 2020 – a balanced scenario to meet Europe's renewable energy target*.

EurActiv (2008), *MEPs give major boost to renewables industry*, September 12, 2008.

European Commission (2007), *European Strategic Energy Technology Plan*.

European Commission (2007), *Limiting Global Climate Change to 2 degrees Celsius, The way ahead for 2020 and beyond*, Communication from the Commission to the Council, the European Parliament, the European Economic and Social Committee and the Committee of the Regions.

European Commission (2008), *Annex to the Impact Assessment*, Commission Staff Working document.

European Commission, Directorate-General for Energy and Transport (2008), *European Energy and Transport, Trends to 2030 – Update 2007*, prepared by NTUA with the PRIMES model.

European Commission (2008), *Clarifications regarding the definition of final energy consumption in Article 2(c) of the RES directive*, Non-paper.

Wallenborn et al. (2006), *Huishoudprofielen nader omschrijven voor een efficiënter energiebeheer aan de vraagzijde*, Scientific Support Plan for a Sustainable Development Policy (SPSD II), Research Contract CP/50.