Macroeconomic impacts of the low carbon transition in Belgium

FINAL REPORT – October 2016

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Prof. Th. Bréchet (UCL),
the Belgian Federal Planning Bureau
and Oxford Economics

TOWARDS A
LOW CARBON SOCIETY

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Colophon

This study was conducted by CLIMACT in collaboration with Prof. Th. Bréchet, the Federal Planning Bureau and Oxford Economics at the request of the Climate Change Service of the Federal Public Service Health, Food Chain Safety and Environment.

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An electronic copy of this report and a summary of the main findings are available on
http://www.climatechange.be/2050/scenario-analysis

Abstract

The study 'Scenarios for a low carbon Belgium by 2050' (see www.climatechange.be/2050) has shown that it is technically possible to achieve an 80 to 95% reduction of greenhouse gas emissions by 2050.

What are the socio-economic consequences of such a transition? This study aims to provide an answer to this question by examining the macroeconomic impacts of the low carbon transition, particularly regarding growth, competitiveness, employment and co-benefits.

The study shows that a drastic reduction of greenhouse gas emissions is compatible with an economic growth that is comparable to the level of – but different in terms of content from – the growth observed in a business-as-usual scenario. It can also lead to net job creation, although impacts at sector level are mixed. In terms of competitiveness, industrial sectors gain from the transition, provided the international context and the specificity of certain companies and value chains are adequately taken into account when defining policies and measures. Finally, emission reduction policies may lead to considerable advantages in many other fields.

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I. CONTEXT

Heads of state and government delivered a strong message at the COP21. They agreed to hold the global average temperature rise well below 2°C above pre-industrial levels and to pursue efforts to limit this temperature increase to 1.5°C. This means that worldwide greenhouse gas (GHG) emissions need to come close to zero or even become negative during the second half of the century. To achieve this objective, the EU and its member states have committed to achieving an 80% to 95% reduction in GHG emissions by 2050, compared to the level in 1990, this within the context of the reductions that will have to be made by industrialised countries.

Though achieving such a reduced level of GHG emissions is a challenge, the study "Scenarios for a low carbon Belgium by 2050" [1] demonstrates that it is technically feasible by means of technologies which mostly already exist today and without necessarily affecting the level of industrial production. Several pathways can be taken based on various technological choices and behavioural changes.

This report focusses on key macroeconomic issues regarding this low carbon transition in Belgium. It investigates the impacts of the transition on growth, employment, competitiveness and the related co-benefits. However, it captures neither the microeconomic aspects of the transition, nor the implementation of the related policies and measures.

The study was conducted by CLIMACT, the Federal Planning Bureau, Oxford Economics and Professor Th. Bréchet from the Catholic University of Louvain on behalf of the Climate Change Service of the Federal Public Service Health, Food Chain Safety and Environment.

The report is organised as follows. The overall methodology is presented in Section II. The main results of the impact analysis related growth, employment and competitiveness are described in Section III, while de sectorial impacts are discussed in Section IV. Section V is devoted to an overview of the co-benefits of the low carbon transition and the main findings are summarised in section VI. Appendices are available online and provide the reader with further details on the methodology used and analyses performed.

1 See www.climatechange.be/2050.

II. METHODOLOGY

A. Introduction

In addition to a detailed literature review, the methodology is based on complementary macroeconomic models at the Belgian and international levels. The quantitative results from these models are complemented by a bottom-up model based on domestic input-output multipliers, and by qualitative analyses collected during various consultations conducted with key experts and stakeholders. Their contribution is gratefully acknowledged.[2]

The two macroeconomic models used in the study are HERMES from the Belgian Federal Planning Bureau and GEIM from Oxford Economics. GHG emissions reduction measures and actions based on main low carbon levers as defined in the technical study "Scenarios for a low carbon Belgium by 2050", have enriched the two models. Of these scenarios, the balanced "CORE" scenario has been analysed extensively.

Therefore, the methodology aims at overcoming the main limits of each model by providing larger and more comprehensive insights than what each of them could provide separately.

B. Starting from the "scenarios for a low carbon Belgium by 2050"

Different pathways make it possible to achieve an 80 to 95% reduction of greenhouse gas emissions in Belgium by 2050. In the study "Scenarios for a low carbon Belgium by 2050", a set of such pathways have been defined, in a participative way, on the basis of the low carbon levers identified in the OPEERA model.[3]

The levers result in specific GHG emissions reduction measures and actions (hereinafter referred to as "low carbon measures and actions") that define each of these pathways and serve as inputs in the models used in the present analysis. The low carbon measures and actions include, among others, the following elements:

- Transport: reducing travel demand, shifting to public transport, improving the efficiency of various transport modes, shifting to electric mobility.
- Buildings: increasing compactness of new buildings, improving building insulation, improving the efficiency of heating systems, electrifying heating.

2 However, experts and stakeholders consulted in the context of this study do not necessarily share the analyses and the conclusions described in this report.

3 OPEERA stands for Open-source Emissions and Energy Roadmap Analysis. OPEERA is an expert-driven model developed by CLIMACT in collaboration with The Department of Energy and Climate Change (DECC) of the United Kingdom.

– Industry: improving the efficiency of industrial processes, shifting to low carbon energy sources in the industry, applying CCS to some of the largest installations.
– Agriculture: changing diets, applying specific agricultural techniques.
– Energy supply: shifting to renewable energy sources, increasing use of biomass.

The present analysis is mainly based on the 'CORE' scenario[4] that balances the efforts across the emitting sectors and the type of measures and actions (behavioural vs technological). Where appropriate, the analysis describes the potential differences with other scenarios such as the 'BEHAVIOUR', the 'TECHNOLOGY' or the '-95% GHG' scenarios.

Figure 1 below shows the total energy system costs, as calculated for the scenarios developed in the study "Scenarios for a low carbon Belgium by 2050".

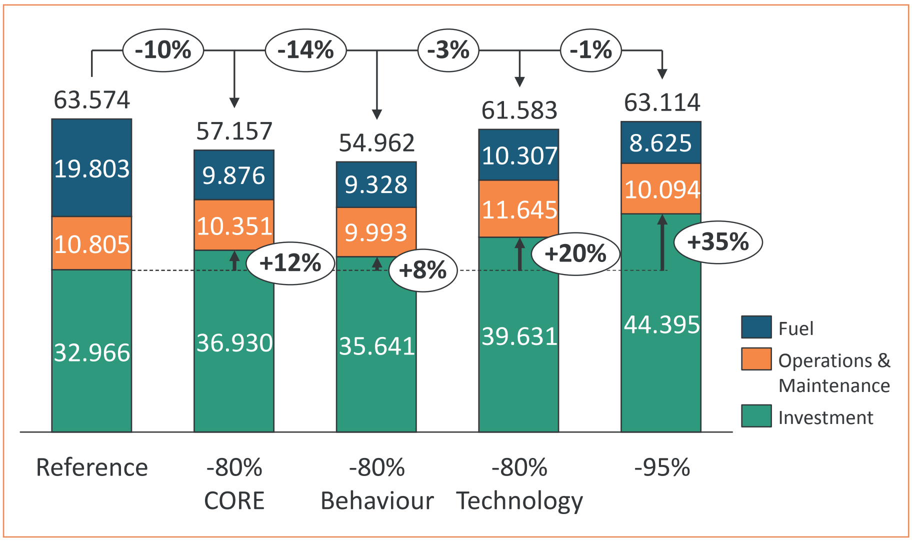


Figure 1. Total system cost, average yearly expenditures undiscounted (2010-2050), EUR_{2013} million, OPEERA

The low carbon scenarios lead to changes in the costs of the energy system (split between investments, fixed and variable operating costs, and fuel costs). These are used as inputs for the modelling analyses performed in this study.

C. An approach based on three models

1. Description of the models

Macroeconomic models are designed to address the key macroeconomic issues.[5] Still, market imperfections, real world inefficiencies, consumer preferences, costs resulting from climate change, potential lock-ins or co-benefits are not always fully represented by any single macroeconomic model.[6]

4 All scenarios are described in detail in the study "Scenarios for a low carbon Belgium by 2050". The website dedicated to the study www.climatechange.be/2050 provides extensive study details.
5 Annex 5 includes details on literature review.
6 For a discussion of the limits computable economic models, see for instance New Climate Economy (2014), "Better growth, better climate".

This study is based on three different models, complemented by discussions held with stakeholders in order to reflect the complexity of the debate and to capture the range of potential impacts.

HERMES (Belgian Federal Planning Bureau)[7]

HERMES is a national macrosectoral econometric model that breaks down the Belgian economy into 15 sectors. The model analyses the interactions between the energy system and the economy. It is used by the Belgian authorities to forecast and simulate the impact of policy measures and exogenous shocks on Belgian macro and sectoral indicators (GDP, added-value, employment, public accounts, external trade balance, etc.) up to 2030.

GEIM (Oxford Economics)[8]

The Oxford Economics 'Global Energy Industry Model' (GEIM) is a hybrid general equilibrium model that encompasses some econometric equations and exogenous technological features. It is designed to assess the macroeconomic impacts of emissions abatement policies at global and regional levels. The model, whose forecast horizon currently extends to 2050, covers 35 countries[9] which jointly account for 77% of the global GDP. GEIM is used to analyse the impacts of low carbon policies and measures on global energy price dynamics and on industrial competitiveness.

OPEERA-Input/Output (CLIMACT)

OPEERA is a techno-economic simulation model based on energy accounting (balancing energy demand and supply) which was populated with data based on extensive consultations with experts. It provides HERMES and GEIM with bottom-up information on detailed low carbon levers and it was complemented by an add-on with input-output activity and employment multipliers,[10] thereby becoming the OPEERA-Input/Output model (OPEERA-IO). The expenditure implications of each lever are split across its specific value chain, based on the various activity sectors involved. The multipliers enable the estimation of the direct and indirect impacts of investments (positive or negative) on income and employment in the Belgian economy at sectoral level.

2. Innovative approach

The low carbon measures and actions defined in the technical study lead to net required energy system expenditures (e.g. an increase of capital expenditures and a decrease of fuel expenditures) as illustrated in Figure 1 above. The changes in expenditure levels between the REFERENCE scenario and the low carbon scenarios, are allocated by sector of the economy based on the relevant value chains, and they serve as input for the three models to assess the

7 Annex 2 includes assumptions and results of HERMES modelling exercises.

8 Annex 3 includes assumptions and results of GEIM modelling exercises.

9 These include the 27 EU countries, the USA, Japan, China, India, Brazil, Mexico, South Africa and South Korea. The rest of the world is modelled as a single 'Rest of World' block.

10 Provided by the Federal Planning Bureau and the National Bank of Belgium. The inter-sectoral multipliers break down the Belgian economy into 62 sectors, enabling the analysis of the impact, of specific bottom-up measures, at a detailed sectoral level.

impact of the low carbon scenarios on Belgian macroeconomic indicators, as illustrated in Figure 2 below.

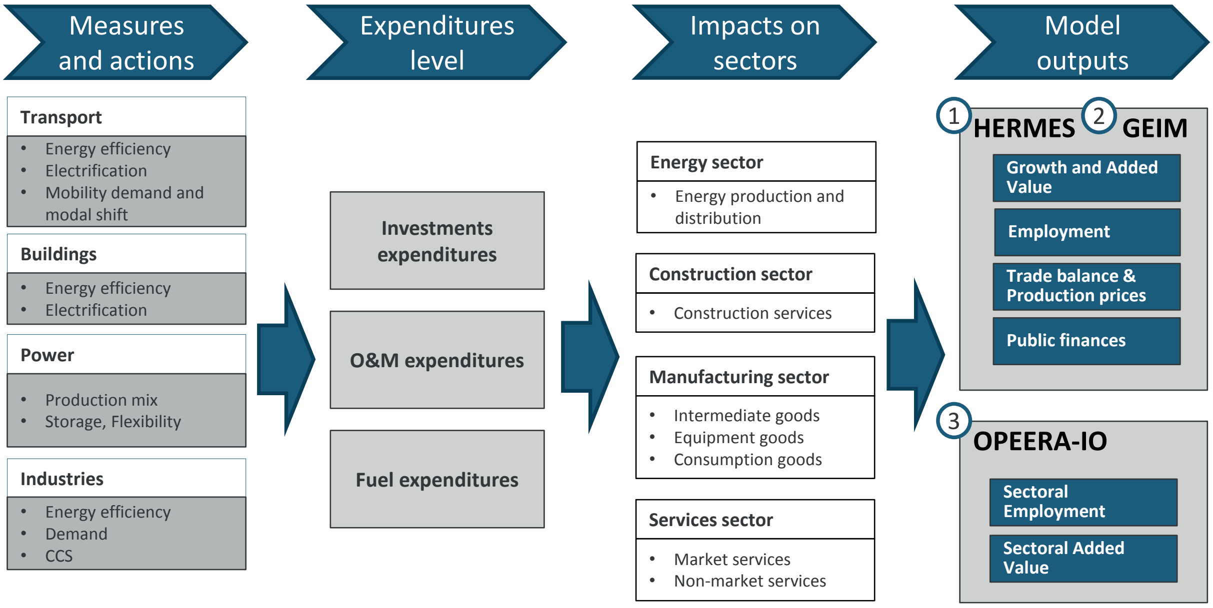


Figure 2. Illustration of the integration of low carbon measures and actions in the 3 models

During the course of the project (and specifically during stakeholder consultations) many qualitative insights have been collected regarding potential impacts on specific sectors of the Belgian economy resulting from the transition to a low carbon society. Not all of those insights are always well-reflected in the results of the models and for this reason they are summarised in specific text boxes throughout the report.

The following section describes the scenarios that have been assessed using the three models.

D. Scenarios Definition

As modelling results are described as differences between the low carbon scenarios and the REFERENCE, it is important to understand how the REFERENCE scenario and the low carbon scenarios are defined.

As briefly mentioned in Section B above, the main low carbon scenario analysed is based on the 'CORE' scenario defined in the study "Scenarios for a low carbon Belgium by 2050". The 'CORE' scenario was selected as it reaches the objective of 80% GHG emissions reduction by balancing the efforts across emitting sectors and type of measures and actions. Where appropriate, the analysis describes the potential differences with other low carbon scenarios, including the scenario reaching a reduction of 95%.

1. REFERENCE scenario

The HERMES REFERENCE scenario has been elaborated by the Federal Planning Bureau for the period 2015-2030.[11] It assumes unchanged policies and thus includes the decisions formally approved by the public authorities. This scenario leads to a reduction of 16% of CO_2 emissions in 2030 (vs 1990) and a GDP average real growth rate of 1.4% per year. It assumes a carbon price in the ETS sectors that gradually increases from €5 today to €35 in 2030 (which is in line with EU literature[12]). Inflation is assumed to remain below 2% during the period 2016-2030, notably because wage increases are assumed to be lower than productivity gains. Renewable energy sources are assumed to represent 39% of gross electricity generation by 2030. More details can be found in Annex 2 to this report.

The GEIM REFERENCE scenario[13] leads to a flat evolution of CO_2 emissions in 2050 (vs 2015) and a GDP average real growth rate to 2050 of 1.5% per year. A carbon price in the ETS sectors gradually increases from €5 today to €100 in 2050. The global growth rate is assumed to be on average 2.4% per year to 2050. Current policies remain in effect and no new emissions abatement policies are introduced. Global emissions rise 0.7% per year on average in the baseline to 2050, primarily due to rising emissions in emerging markets. More details can be found in Annex 3 to this report.

THE OPEERA-IO REFERENCE scenario includes existing policies and assumes that beyond existing targets or incentives the parameters continue to develop at the same pace. It does not include additional policies to reduce GHG emissions. The scenario takes into account the objectives of the 2020 EU Climate-Energy package and the federal and regional agreed climate-energy policies. It leads to a flat evolution of CO_2 emissions in 2050 (vs 2015) with associated investments, O&M and fuel expenditure levels. OPEERA-IO scenarios don't include any assumptions on carbon price level, fiscal policy or international context. More details can be found in Annex 4 to this report.

2. CORE LOW CARBON scenario

The low carbon scenarios lead by definition to much higher GHG emission reductions. The "CORE LOW CARBON" scenario assumes the implementation of a global carbon price combined with a specific assumption on the use of public revenues, in the context of a coordinated international policy.

These three key elements are described below and summarised in Table 1.

1. CO_2 emissions evolution and low carbon measures and actions

The CORE LOW CARBON scenario includes CO_2 emission reductions that result from the low carbon measures and actions defined in the CORE scenario from the study "Scenarios for a low carbon Belgium by 2050". Complementary anal-

11 More specifically, this scenario was prepared for the new 2014-2019 projection, which was published in September 2014, and was used, inter alia, for the report "Projections of GHG Emissions by 2030 for Belgium" published by the Federal Planning Bureau in February 2015.

12 European Commission (2014), "Impact Assessment - A policy framework for climate and energy in the period up to 2030".

13 REFERENCE scenario is based on IEA data from 2014.

yses have been performed on other scenarios such as the 95% GHG REDUCTION scenario and are presented when relevant.

2. Carbon price and accompanying fiscal policy

The carbon price level is defined based on projections from the European Commission[14] as being sufficient to trigger the required low carbon measures and actions to reach -80% GHG emissions at EU level. The accompanying fiscal policy consists in recycling –within the economy– the public revenues from the carbon pricing through a reduction of social security contributions. Complementary analyses on public revenues' recycling options have been performed and are presented when relevant.

3. International context

A global action to mitigate climate changes is assumed to take place. The low carbon measures and actions and the carbon price with its accompanying fiscal policy are simultaneously introduced in all countries trading with Belgium. A complementary analysis on the possibility of the EU moving alone on climate change mitigation (EU ONLY context) has been performed and is presented when relevant.

The main results of our analysis are presented below. More details can be found in Annex 1.

Table 1.
CORE LOW CARBON scenario key elements

<table>
<tr><th></th><th>Hermes</th><th>GEIM</th><th>OPEERA-IO</th></tr>
<tr><td rowspan="2">1 CO_2 emissions evolution & low carbon measures</td><td>• -46% in BE (2030 vs 1990) (in line with -80% in 2050)</td><td>• -80% in EU (2050 vs 1990)</td><td>• -46% in BE (2030 vs 1990)
• -80% in BE (2050 vs 1990)</td></tr>
<tr><td colspan="3">• Measures and actions defined in the CORE scenario from the study “Scenarios for a low carbon Belgium by 2050”</td></tr>
<tr><td rowspan="2">2 Carbon price & fiscal policy</td><td colspan="2">• Carbon price in all sectors (gradually to 40€ in 2030)
• ETS (+5€ in 2030, from 35€ to 40€)
• Rises to 150€ in 2050</td><td>• N/A</td></tr>
<tr><td>• Recycling of carbon revenues through reduction in personal and employer’s social security contributions</td><td>• Recycling of carbon revenues through reduction of government deficit</td><td>• N/A</td></tr>
<tr><td>3 International context</td><td colspan="2">• Global action: low carbon transition policies in EU and the rest of the world</td><td>• N/A</td></tr>
</table>

14 European Commission (2014), “Impact Assessment - A policy framework for climate and energy in the period up to 2030”.

III. RESULTS: GROWTH, EMPLOYMENT AND COMPETITIVENESS

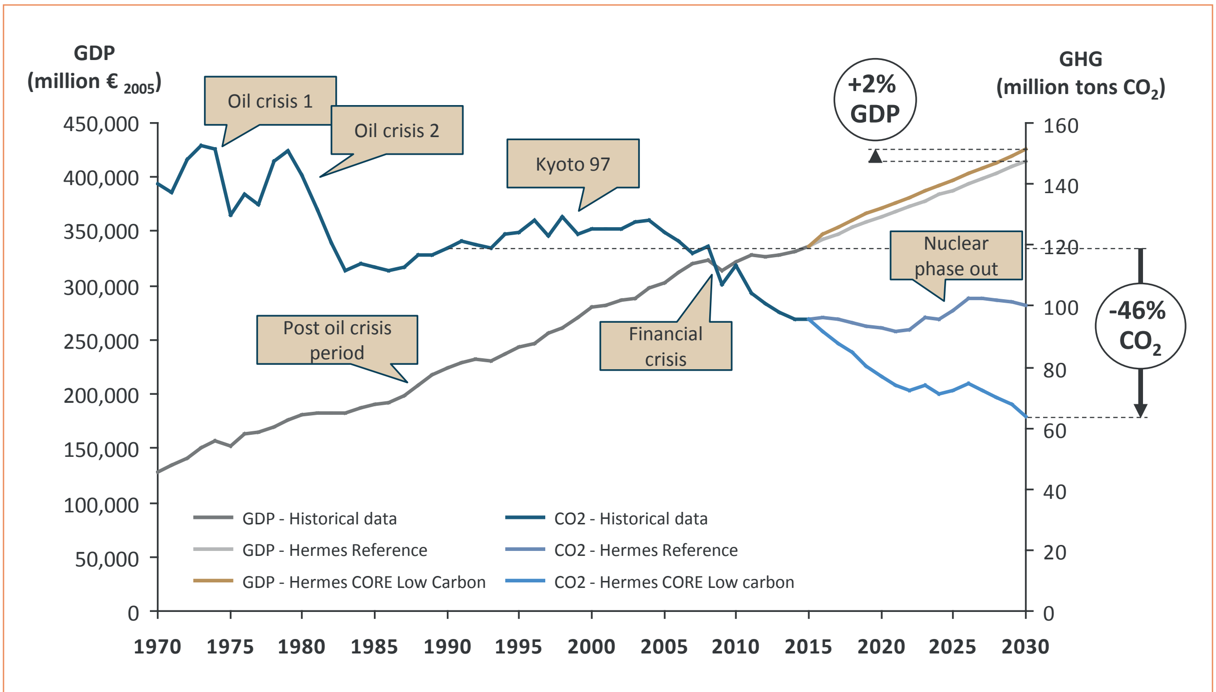
A. Growth and Macroeconomic Indicators

The literature review highlights that large reductions in GHG emissions may have a limited impact on the economic growth path, whether negative or positive (see Annex 5). The impact of low carbon strategies tested in a variety of models typically ranges between -2% and +2% on the GDP level in the medium term in the EU. The differences are explained by the type of model used, the timeframe, and specific assumptions.

The impact on GDP is slight compared to the underlying expected growth up to 2030: an impact of about ± 2% on the GDP level would represent a gain or a loss of about 1 year of growth over 15 years, or a gain or a loss of 0.16% of annual growth rate during 15 years. However, these aggregate impacts on GDP only tell part of the story. The low carbon transition would lead to other benefits, such as a reduction in urban pollution, or the avoided adverse effects of climate change on the economy (described below in Section V). At the same time, some of the costs of the transition are not taken into consideration in this exercise, for example the friction related to shifting employment among activity sectors and the required education efforts.

The results of the study are within the high range of the impacts identified in the literature. This is explained by the innovative approach taken, including in particular a low carbon scenario that explicitly addresses the 'behavioural

Figure 3.
GDP and CO_2 emissions evolution in Belgium, EUR $_{2005}$ million / million tons CO_2 in that year, HERMES



change' dimension. The figure below shows historical data and projections for GDP and CO_2 emissions in Belgium for the REFERENCE scenario and the CORE LOW CARBON scenario based on HERMES. The CORE LOW CARBON scenario leads to a slightly higher GDP for Belgium than the REFERENCE scenario in 2030.

CO_2 emissions are 46% lower in 2030 compared to 1990 in the CORE LOW CARBON scenario. This scenario leads to an increase of +2% of the GDP level in 2030 compared to the REFERENCE scenario. As described below, this increase illustrates the inclusion of the low carbon measures and actions, a carbon price with an adequate accompanying fiscal policy and a global climate change mitigation policy.

When comparing the historical evolution of the GDP with the evolution of CO_2 emissions, a decoupling of emissions from GDP growth clearly appears since 1970.[15, 16] Looking forward, the observed decoupling of CO_2 emissions and GDP is projected to continue.

Indeed, results from the HERMES model show that it is possible to achieve economic growth in Belgium while addressing climate change through profound economic and societal transformations. Households and firms invest a larger part of their revenues in energy efficiency and low carbon infrastructures instead of purchasing other intermediary or consumer goods. This leads to both a private demand push in investments for low-carbon technologies and large energy bill reductions for households and firms. Those two effects are combined with the positive macroeconomic spillovers related to recycling of the carbon revenues and the internationally coordinated policy that support the impacts of the low carbon measures and actions. All in all, the measures introduced drive economic activity upwards in most activity sectors.

As mentioned above, the CORE LOW CARBON scenario has some effects on the labour market, households' real disposable income and firms' gross operating surplus. But these effects turn out to be limited in magnitude. Table 2 shows that in the medium term (2030), the scenario drives the consumer price index up by 1.68% with respect to the baseline, which is marginal. But at the same time, households' real income increases by 0.27% because of the higher job creation and energy savings, and the firms' gross operating surplus increases by 1.22 in percentage point because of larger activity creation and energy savings too.

Table 2. Impacts on households and firms in 2030, CORE LOW CARBON vs REFERENCE scenario, HERMES

	Change in CORE LOW CARBON vs REFERENCE
Households' net disposable income	+0.27%
Firms' gross operating surplus (EBITDA)	+1.22 (change in percentage point)

15 Except during post oil crisis period from mid-eighties to mid-nineties.

16 Factors such as the financial and economic crisis or the larger proportion of embedded emissions in Belgian imports might have played an important role in decreasing CO_2 intensity of the European economies. But looking forward, those factors don't impact the study results as assumptions don't differ between reference and low carbon scenarios.

B. Employment

The literature review indicates that the low carbon transition has a limited impact on total employment at EU level, although the impact tends to be positive, particularly when the recycling of the carbon revenues is taken into account. The impact on employment in the low carbon scenarios at the EU level typically ranges between -0.5% and +1% (see Annex 5).

The HERMES modelling results show that the CORE LOW CARBON scenario leads to the creation of ~80,000 additional jobs in 2030. This represents an increase of 1.7% in comparison with the REFERENCE scenario.

In Figure 4 below, the impact of the CORE LOW CARBON scenario, on job creation in the Belgian economy, is shown for each sector in 2030.

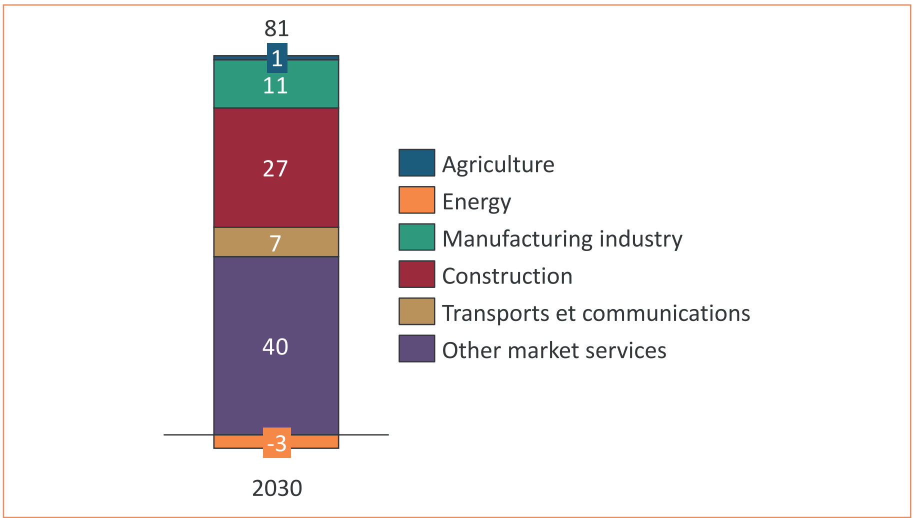


Figure 4.
Job creation by sector in 2030 in Belgium, thousands of jobs, CORE LOW CARBON wrt REFERENCE scenario, HERMES

The sectors of construction and market services are the ones in which most jobs would be created. These sectors benefit most from the large investments in low-carbon technologies that would be triggered by robust and predictable policies. Those sectors are also labour-intensive and therefore benefit greatly from the recycling of public revenues in the reduction of social security contributions.[17] In the CORE LOW CARBON scenario, the additional public revenue from carbon pricing represents 0.5% of the GDP or about €3.5 billion in 2030.[18] The effect of the accompanying fiscal policy alone is responsible for the creation of 24,000 jobs.

In some sectors (such as construction or intermediary goods production), the analysis highlights the potential issues related to capacity constraints. For example, the push in demand for new buildings and the additional retrofitting of buildings leads to pressure on production capacities, which translates into a gradual increase in production prices. This demonstrates the importance both

17 Other recycling options have been tested and discussed (see Annex 1, as well as the literature, for example D. Bassilière, F. Bossier, L. Masure, P. Stockman, Bureau Fédéral du Plan (2010), "Variantes de réduction des cotisations sociales et de modalités de financement alternatif".

18 As a reminder, the level of the tax/price in low carbon scenarios is equal to €40 in the non-ETS sectors and an additional €5 in the ETS sector. The carbon price for industries is equal to €35 in the REFERENCE scenario.

of policies that support the development of those sectors, in particular with regard to low carbon activities, and in terms of spreading the required investments over a long period of time.

Figure 4 above also shows that the low carbon measures and actions negatively impact the energy sector with an overall loss of 3000 jobs. This includes the impact on fossil fuel-producing and refining industries, and on the power generation and distribution sector.[19] These results highlight the negative impact of the overall reduction in energy demand. However, the analysis shows that actions and measures within the power sector (such as the change in the electricity production mix) have a positive net effect on overall employment in Belgium. This is due to higher investments in new renewable power capacities and power infrastructures, often related to highly labour-intensive sectors. These issues are further discussed in Section IV.

The analysis also shows that the low carbon measures and actions defined in the CORE scenario from the study "Scenarios for a low carbon Belgium by 2050" have different impacts across the overall economy. For example, building new renewable energy power plants impacts all sectors of the economy: technical services are in charge of project design, development and management; the construction sector is involved in the construction of the plant itself; manufacturing industries provide all subcomponents; non-technical services provide finance and insurance and the energy sector operates the plant.

Each category of low carbon actions and measures drives job creation through specific value chains, which is captured by the HERMES model.[20] The analysis shows that there is no one-to-one relationship between reduction in emissions and job creation. As illustrated in Figure 5, the low carbon actions and measures implemented in buildings and industry lead to a 56% of reduction of emissions while contributing to 78% of the jobs created in the CORE LOW CARBON scenario in 2030. Section IV further describes the results of complementary analyses carried out in the OPEERA-IO model at the sectoral level.

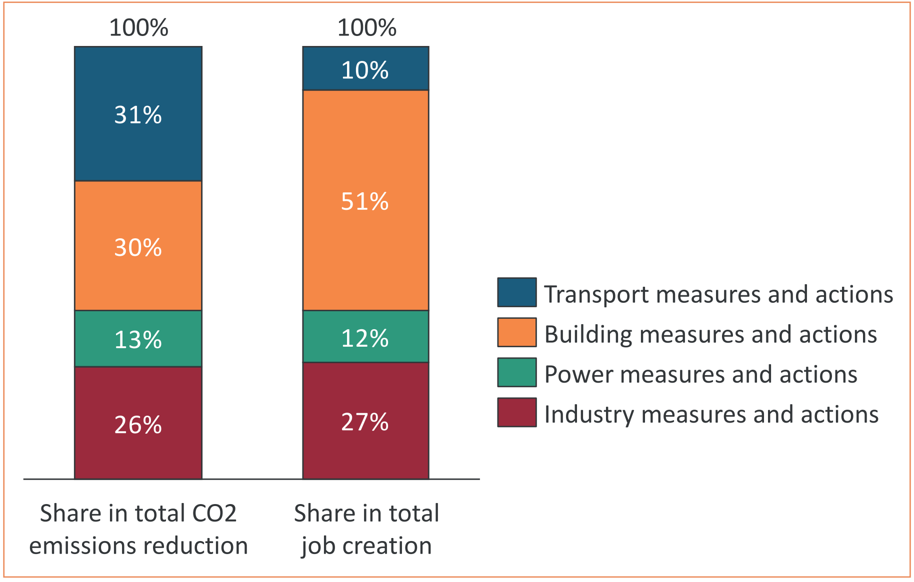


Figure 5. Contribution of low carbon measures and actions to CO_2 reduction and job creation (out of the contribution of the carbon price with accompanying fiscal policy and the international context), CORE LOW CARBON scenario HERMES

19 The energy sector is not detailed enough in HERMES to isolate the impact on energy related sub-industries.

20 Those related to the final and intermediary demand and those related to the international development.

C. Energy Prices

1. Energy prices throughout the World

GEIM assesses the impact of the CORE LOW CARBON scenario on global energy prices. A complementary analysis assuming that the EU would be moving alone on climate change mitigation (EU-ONLY context) has been performed and is also presented. The model calculates energy prices endogenously, enabling the analysis of the impact on fossil fuels, electricity and average energy prices.

Impacts on GLOBAL fossil fuel prices

Even though the EU's fossil fuel consumption is relatively small compared to global consumption, low carbon measures set at EU level (EU-ONLY context) have a deflationary impact on global fossil fuel prices (the impact is calculated based on the price elasticity derived from historical data, and the level of reduction in EU fossil fuel consumption). The analysis shows that other regions of the world (such as the US and China) freeride on the EU's efforts to decrease its GHG emissions and benefit from lower global fossil fuel prices.

Fossil fuel prices are substantially lower in the GLOBAL ACTION context as this yields a more substantial decline in the global demand for fossil fuels.

Global fossil fuel prices in 2050	EU-ONLY	GLOBAL ACTION
Coal	-12%	-46%
Oil	-21%	-41%
Gas	-28%	-52%

Table 3.
Fossil fuel prices evolution in 2050, % change in real prices (pre-tax) in that year wrt REFERENCE scenario, GEIM

Impacts on energy prices per region

In the GLOBAL ACTION context, real average energy prices in the EU decline relative to the REFERENCE scenario, as the low carbon measures and actions along with carbon tax in the rest of the world lead to lower demand and lower fossil fuel prices (see Table 4). Prices in the US and China are higher in the GLOBAL ACTION compared to the EU-ONLY context as they also implement a carbon tax[21] and their energy mix is more carbon-intensive than Europe's. The slowdown in the world coal price does not fully offset the impact of the carbon tax in the long run, so the energy bill for consumers in a coal-based energy system (such as in China or the US) in the CORE LOW CARBON scenario is actually higher than in the REFERENCE scenario. This also reflects the shift to electricity, of which the prices are rising more in real terms in the US and China due to the higher costs arising from the shift to renewables-based generation.

In the EU-ONLY context, the EU's energy demand falls, leading to a decline in global energy prices. But the decline is not sufficient to offset the carbon price

21 EU has some carbon taxation in the REFERENCE scenario, so the change in the level of the tax in the CORE LOW CARBON scenario is smaller than for the US and China (i.e EU goes from €100/tCO_2 to €150/tCO_2 in 2050 but US/China go from €0 to €150/tCO_2).

introduced in the EU. In essence, the US and China freeride on the EU's efforts, as a benefit from the decline of fossil fuel prices. Energy price reductions are higher in the US than in China as their energy mix is more heavily based on oil and gas, which see larger reductions in volume and prices than coal.[22]

Table 4. Energy prices evolution in 2050, % evolution in real prices that year wrt REFERENCE scenario, GEIM

Regional energy prices in 2050	EU-ONLY	GLOBAL ACTION
EU28	+8.0%	-1.5%
US	-8.5%	+9.6%
China	-1.7%	+23.0%

Impacts on electricity prices per region

In the GLOBAL ACTION context and compared to the REFERENCE scenario, Europe experiences lower nominal electricity prices due to the falling gas price. Both China and the US decrease coal consumption in the power sector, but they still remain substantially coal-intensive in comparison to the EU. As noted above, the falling coal price does not fully offset the impact of the carbon price, so coal prices are higher than in the REFERENCE scenario. Higher after-tax coal prices, in addition to the costs of shifting to renewables, contribute to the increase in electricity prices in both the US and China compared to the REFERENCE scenario.

In the EU-ONLY context, the decline in fossil fuel prices leads to lower electricity prices in the US and China. As explained above, countries such as the US will benefit more than countries in other regions, such as China, because their energy mix is more heavily based on oil and gas, which see larger reductions in volume and prices than coal. The net impact of higher renewable-based electricity and lower fossil-fuel prices lead to a limited change of prices in Europe compared to the REFERENCE scenario.

2. Energy prices in Belgium

Using the HERMES model, it is possible to analyse the evolution of energy prices in Belgium.[23]

In the CORE LOW CARBON scenario, on average energy prices increase more for carbon intensive fuels such as solid and liquid fuels than for natural gas and electricity, and more for households and services than for the industry when compared to the REFERENCE scenario. This is due to the limited increase of the carbon price (+€5 by 2030) in the ETS sectors with regard to the REFERENCE scenario, while the carbon price in 2030 for households and services goes from €0 in the REFERENCE scenario, to €40 in the CORE LOW CARBON scenario.

Electricity prices are slightly higher in the CORE LOW CARBON scenario than in the REFERENCE scenario. In 2030, the impact of the carbon tax combined

22 China is more coal intensive than the US (in terms of power, and given the larger share of heavy industry in the economy) so its fuel mix is weighted more heavily to the fuel that is seeing the smallest decline in price.

23 As commodities prices are exogenously introduced in the model, prices are influenced by the introduction of the carbon price (for all energy sectors) and the assumptions on production and balancing costs (for electricity only).

with the increased balancing costs and distribution costs are partly compensated by the decreasing production costs (due to the progressively lower cost of renewables). However, it is only after 2030 (beyond the timespan of the HERMES model) that the cost of renewables decline much further.[24, 25] Their increased share in the power mix, in a low carbon scenario, then lead to similar electricity costs as those in the REFERENCE scenario, in the medium to long term.

D. Competitiveness and International Trade

The Impact of current and potentially new climate policies and measures on firms' competitiveness is at the centre of the debate, dealing with important questions such as how to ensure a level playing field, how to tackle carbon leakage risks or how to compensate firms for possible energy price differentials with major competitor countries.

This section has a double objective. The first objective is to assess, with the GEIM model, the differences in sectoral value added for the CORE LOW CARBON scenario and its variant (EU-ONLY context). Results are shown at the EU level as this is the most relevant level for large industrial emitters of GHG. The second objective is to assess, with the HERMES model, the specific impact on trade balance for Belgium.

1. Competitiveness and trade at international level

The impact of the low carbon scenarios on competitiveness is analysed with the GEIM model. The analysis provides a comprehensive representation of international trade patterns while taking account of some sectoral details. The analysis leads to the following findings.

A GLOBAL ACTION context is positive for EU exports

Coordinated action at the global level would have a slightly positive impact on EU exports (+0.5% compared to the REFERENCE scenario) and on the industry value added in Europe (+2.6% in 2030 in the EU vs only +1.3% in China). This limited positive impact on competitiveness is due to greater levels of energy efficiency and larger reductions in fossil fuel consumption in the EU compared to China, which leads to a competitive advantage in a future with a global carbon price.

An EU-ONLY context has a limited impact on EU exports

Analyses with the GEIM model show that EU exports would increase slightly (+0.3% compared to REFERENCE scenario) if the EU were to decide to move alone on the low carbon agenda. The increase in the carbon price raises the end-user cost of carbon-based energy in the EU-ONLY context, and these

24 The faster than foreseen reduction in PV prices only has a marginal impact on the total weighted average electricity cost.

25 The latest Federal Planning Bureau report on long term scenarios for energy prices confirms similar conclusions.

higher costs, along with the capital costs of investing in energy-efficient technologies, place pressure on output prices. Meanwhile, the reduction in EU energy consumption leads to a decline in global fossil fuel prices, leading energy prices in competitor countries to fall below baseline levels, boosting their competitiveness.

The analysis tends to highlight the importance of a coordinated policy for EU competitiveness. Figure 6 shows the extent to which the GLOBAL ACTION and EU-ONLY contexts impact sectoral gross value added in the EU28.

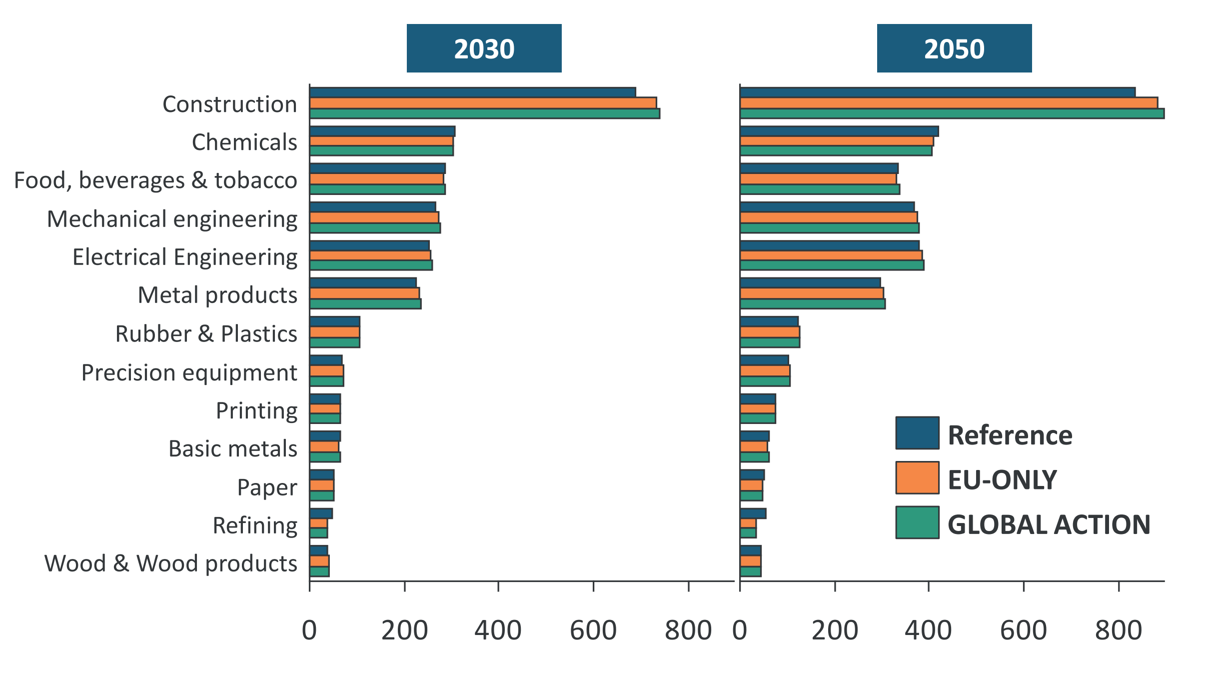


Figure 6.
Sectoral gross value added changes in EU 28 in 2050, in EUR_{2010} billion, GEIM

Impacts at the sectoral level are influenced by the sector's energy intensity, trade exposure, the costs of GHG abatement, and the extent to which the sector benefits from the low carbon transition in general, and specifically from increased capex spending on energy efficiency (as well as some other factors, such as innovation, which are not modelled here). The analysis shows that for most sectors the impact is in the range of ±5% in their Gross Value Added.

In the EU-ONLY context, the sectors that are energy intensive and/or trade exposed tend to fare more poorly compared to the REFERENCE: the change in energy prices has a larger impact on their competitiveness. Therefore, sectors such as chemicals, basic metals and paper are most negatively impacted (see Annex 3 for further details).

In the GLOBAL ACTION context, sectors that are more energy-intensive and/or more trade-exposed tend to see an improvement compared to the EU-ONLY context, as the application of the carbon price globally improves their competitive position. The food and beverage sector, the basic metals sector, as well as the metal product sector, see the largest improvements.

The sector that experiences the largest delta between the GLOBAL ACTION and the REFERENCE scenario is the chemicals sector. Energy costs in the EU are falling by a larger percentage than in the US and also particularly in China. This is due to differences in fuel mix and in electricity prices. Though the impact of the low carbon scenario on output in the sector within the EU is negative (-3.7% vs REFERENCE), the sector outperforms the rest of world as the chemicals sector sees a global reduction of -4%, given that the low carbon transition leads to lower sector output.

2. Competitiveness and trade in Belgium

According to the HERMES modelling results, the CORE LOW CARBON scenario shows a balanced impact on the external trade for Belgium (-0.10 % points of GDP in 2030). Although Belgium experiences sharp savings in its foreign energy bill (see Figure 7), the trade balance (out of energy) remains almost neutral. The rise in Belgian exports is driven by a stronger foreign activity and by competitiveness improvements within Belgium. Fossil fuel imports decrease, while imports of equipment and intermediary goods are increased as a result of the demand push.

Figure 7 shows the impact of the Belgian domestic energy savings on the energy trade balance. The energy balance deficit is cut by half in the CORE LOW CARBON scenario compared to the REFERENCE scenario in 2030. Such savings represent ~2% of Belgian GDP in that year.

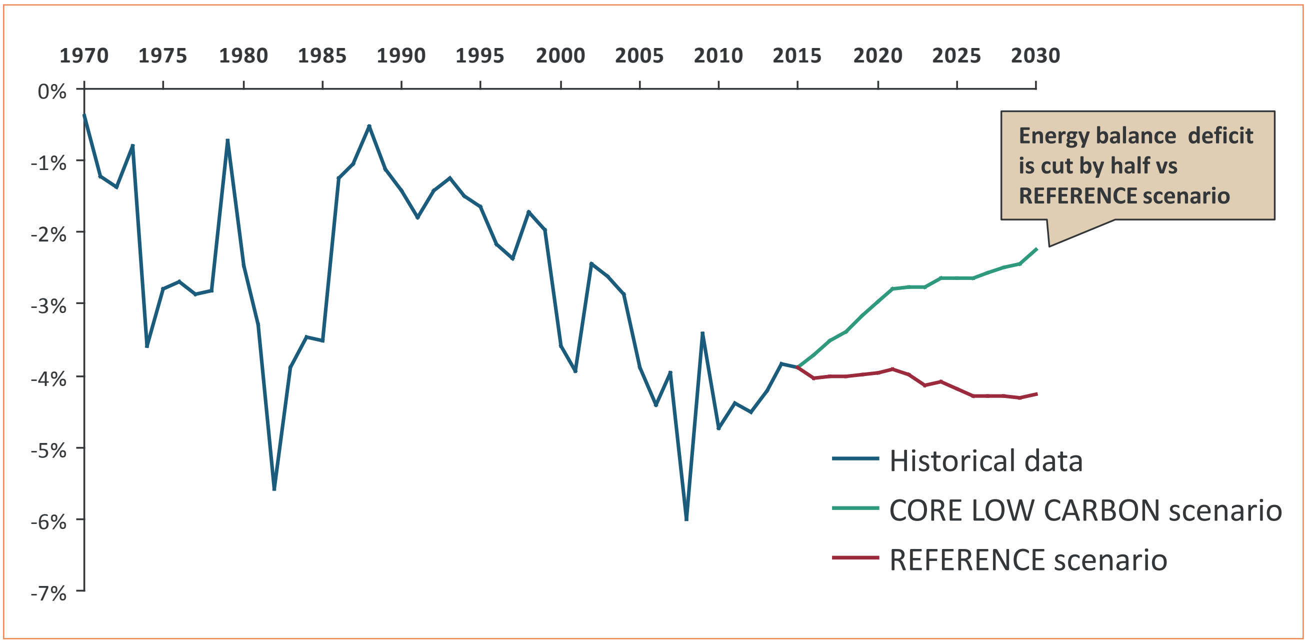


Figure 7.
Belgian energy external balance evolution, % of GDP in that year, historical data and scenarios, HERMES

A. Construction Sector

The CORE LOW CARBON scenario has a positive impact on the construction sector in both the HERMES and the GEIM modelling. It has the largest potential for job creation, with more than 26,500 additional jobs created in 2030 in HERMES (+10% with respect to the REFERENCE scenario).

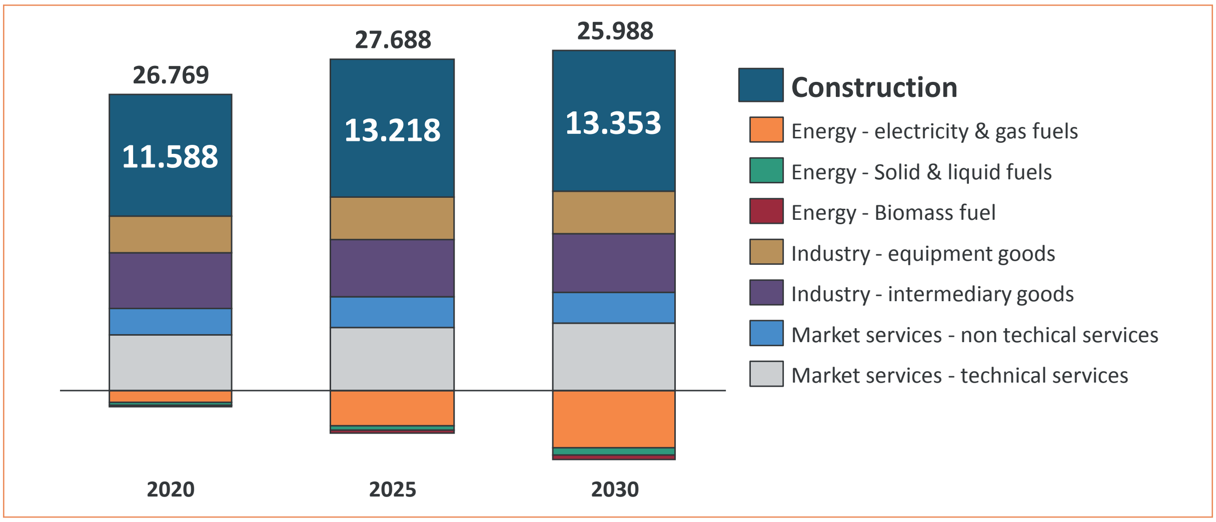
The results from the HERMES model underline the importance of the investments in buildings (such as low carbon buildings, retrofitting or construction of other low carbon infrastructures) to create a demand push, which favours the job-intensive construction sector. The demand push also has a positive impact on the sector's added value (+3.1% in the CORE LOW CARBON scenario in HERMES).

The GEIM modelling results confirm this positive impact: the construction sector benefits from the increase in capital spending and outperforms the rest of the economy.

The OPEERA-IO model enables a more detailed sectoral analysis of the impact of low carbon measures and actions on the construction sector. The results confirm that the measures and actions in buildings are the main driver of jobs creation in the construction sector. Measures and actions in the power and the transport sectors also have a positive but more limited impact on the construction sector.

Figure 8 below gives a more detailed view of the impact on the construction sector resulting from the low carbon measures and actions in residential and commercial buildings.

Figure 8.
Jobs created by low carbon measures and actions in buildings, jobs in that year, CORE LOW CARBON wrt REFERENCE scenario, OPEERA-IO



With more than 13,000 additional jobs created in 2030, the construction sector benefits most from low carbon measures and actions in buildings in the CORE

LOW CARBON scenario. The detailed analysis shows the importance that the retrofitting of buildings has for the creation jobs.[26] However, this result takes no account of the potential additional positive impact of international developments or complementary multipliers effects (tax recycling, inter-sectoral effects, the evolution of households' consumption, etc.), which are captured in the HERMES model.

Figure 8 also highlights how the upstream part of the construction value chain is positively impacted, because low carbon measures and actions in buildings entail an increase in the consumption of intermediary and final equipment (building materials, insulation equipment, electrical and electronic equipment, etc.) and related technical services.

The analysis of other scenarios shows that other 80% GHG emissions reduction scenarios (such as TECHNOLOGY or BEHAVIOUR scenarios) do not lead to a significantly different impact on employment in the construction sector than that of the CORE LOW CARBON scenario (from -5% to +10%). However, the most ambitious scenario (-95% scenario) leads to a significantly higher level of job creation (+38,000 jobs in 2030 compared to the REFERENCE scenario), as a result of an even higher level of retrofitting and a higher rate of new low carbon buildings, entailing an even larger demand push for the economy.

The challenge of "posted" workers in the construction sector: view of experts[27]

The impact of the low carbon transition on employment in the construction sector could be very positive. However, experts argue that the benefits for the local economy could be limited if the regulation on posted workers is not adapted. The European Commission has proposed a revision of the directive to ensure that equal pay and working conditions apply.

Adequate low carbon policies addressed together with labour mobility rules ensuring fair competition could entail a double benefit by reducing emissions, while also supporting local economic development and the creation of qualitative jobs in the construction sector. Qualitative jobs are also key for the success of the transition as high-quality standards are required to implement a high level of emissions reductions. Low carbon measures and actions require specific skills and competencies that could be supported by innovation, education and training.

Public procurement could also play a role in supporting the development of the construction sector through the introduction of specific norms on energy efficiency, requirements regarding sustainability and proximity, and promotion of locally developed low carbon technological solutions.

26 Annex 4 includes details on value chain assumptions and Annex 1 includes details on sectoral results.

27 A "posted" worker is employed in an EU country and sent by his/her employer to another EU country. Moving within the EU for a limited period of time has become increasingly important in the construction industry.

B. Manufacturing Sector

HERMES modelling results show positive impacts in the manufacturing sector for the CORE LOW CARBON scenario. Low carbon investments in all sectors stimulate overall industrial activity creating more than 10,000 additional jobs and 1.5 billion euros of additional gross value added (GVA) in 2030 compared to the REFERENCE scenario. Intermediary and consumption goods are the most positively impacted sectors.

Figure 9 below shows the impact on employment and GVA in the three main manufacturing sectors.

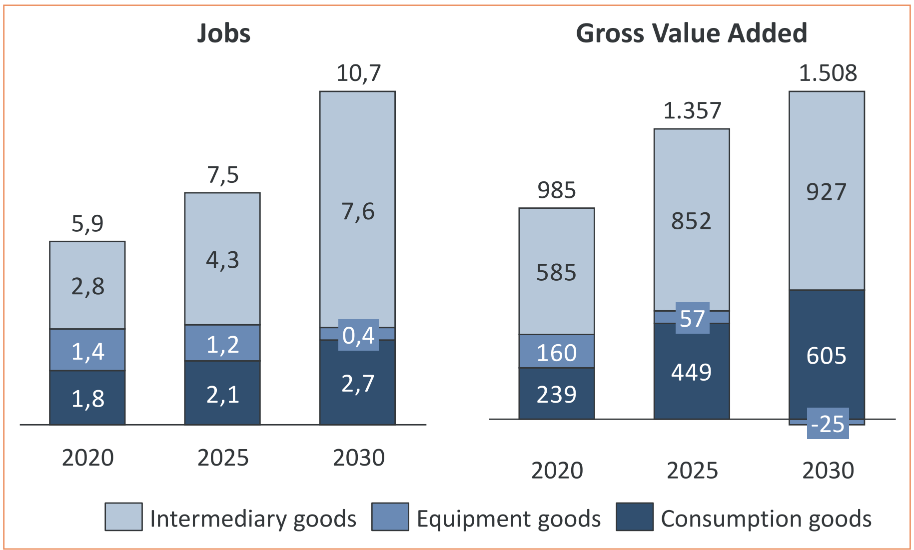


Figure 9. Jobs and Gross Value Added in manufacturing sectors, 1,000 jobs / million EUR_{2013} in that year, CORE LOW CARBON wrt REFERENCE scenario, HERMES[28]

The analysis shows that, in 2030, production prices (production costs + margin changes) decrease in two sectors (-0.83% in intermediary goods and -0.27% in consumption goods) and increase in one (+0.65% in equipment goods). The introduction of a carbon price increases production prices. However, this effect is more than compensated by the recycling policy and the large energy efficiency gains, which drive production costs down in the sectors of intermediary and consumption goods. The demand push described in Section III creates tensions on production capacities, in particular in the equipment goods sector where it drives production prices up, impacting the evolution of employment (slightly positive) and value added (slightly negative) in the sector.

28 Annex 4 includes details on value chain assumptions & Annex 1 includes details on sectoral results.

Firms' specific challenges: view of experts

Low carbon policies could enable firms to increase their energy efficiency in order to compensate for carbon and energy prices increases. But not all sectors or firms have the same potential, not all sectors or firms are able to support the required level of investment to meet such potential.

Qualitative insights collected during the workshops highlight some important elements that are key to preserving the Belgian competitiveness:

- Level-playing field - competitiveness of energy-intensive and trade-open industries should be dealt with at the largest possible geographical scale (i.e., EU or world level).
- Supporting innovation in small and medium size enterprises is an important factor in the support of competitiveness.[29]
- Integrated industrial clusters make it possible to support competitiveness and should be preserved (e.g. the integration of refineries and chemical industries from the north to the south of the country).
- There is vast potential for new low carbon business opportunities in many sectors, e.g. in digitisation, new materials, life sciences, energy-related technologies, etc. The role of public authorities is crucial to create the right conditions to develop and attract new businesses.[30]
- The level of change required to meet the GHG emissions reduction objective will encourage firms to conduct business differently. Innovative initiatives should be supported to develop new business models (e.g. circular economy initiatives), new social practices, new financing solutions, etc.

29 The potentially positive competitiveness impacts resulting from the development of innovative low carbon technologies are not fully reflected in the models used.

30 Car manufacturers that invest in the assembly and manufacture of electric car capacities in Belgium is a good example of an automotive sector opportunity to develop a new innovative cluster of SMEs that would not only attract more investments in the manufacture of low carbon technologies but would boost the local economy as well.

C. Energy Sector

The energy sector faces many challenges since the transition to a low carbon society requires a shift in the way energy is produced and consumed.

As described in the section on employment, the HERMES modelling results indicate a limited but negative impact on employment in the overall energy sector for the CORE LOW CARBON scenario. This includes the impact on fossil fuel-producing and refining industries, as well as on the power generation and distribution sector.[31]

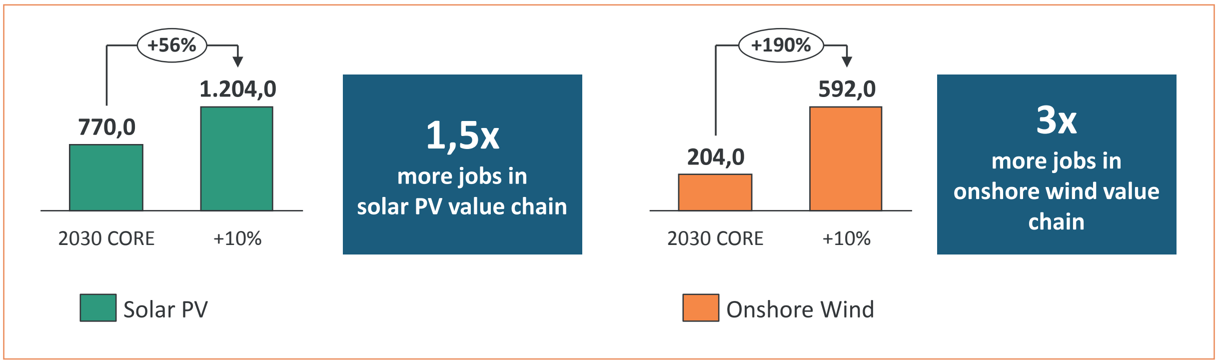
The OPEERA-IO model enables a more detailed analysis of the specific impacts on two main sub-sectors: the power sector and the refining sector.

Within the power sector, investments in new power capacities enable the creation of nearly 4,500 jobs in 2030, in the CORE LOW CARBON scenario, in comparison with the REFERENCE scenario. The highest potential for additional job creation is related to the development of biomass power stations, geothermal power stations, on/offshore wind turbines and solar PV. This potential comes on top of a significant job creation in the REFERENCE scenario which already accounts for large RES deployment.[32] In addition, this result takes no account of the potential, additional, positive impact of international developments or the effects of the complementary multipliers (tax recycling, inter-sectoral effects, the evolution of households' consumption, etc.).

On the other hand, lower investments in gas power stations in the CORE LOW CARBON scenario result in negative impacts on employment.

The value chain analysis shows the high potential for the creation of additional jobs if local businesses increase their market share within the entire value chain of the power sector. Figure 10 below highlights the potential of additional jobs if the Belgian part of the overall value chain should happen to undergo a 10% increase.

Figure 10.
Impact of +10% Belgian part in solar PV and onshore wind development value chain, jobs in 2030, OPEERA-IO[33]



31 The energy sector is not detailed enough in HERMES to isolate the impact on energy related sub-industries.

32 Annex 1 gives further details on scenario assumptions specifically for the power sector.

33 Annex 4 includes details on value chain assumptions and Annex 1 includes details on sectoral results.

The impact on the oil and gas-refining industry has also been discussed with the sector. Any decrease in overall energy demand, and in fossil fuel in particular, would have a negative impact on employment in the sector. However, as Belgian refineries are among the most efficient in Europe, the sector expects Belgian capacities to be maintained even in a low carbon scenario, at least in the mid-term, in order to provide for the remaining demand.

Uncertainties on the evolution of the power sector: view of experts

There is a high level of uncertainty about the evolution of the overall energy system and in particular as regards the power system.

The supply side of the energy system will need to adapt to a growing complexity:

- Changes in electricity demand (electrification and price responsiveness);
- Innovation and new technologies leading to breakthroughs and rapid changes in cost of power generation technologies;
- Increasing decentralisation (e.g., wind, small biomass) and auto-production (e.g., PV, cogeneration);
- Evolution of the network with an increasing share of intermittent production, demand side management solutions, storage and/or back-up requirements.

The uncertainty around the power sector impacts the level and the type of potential economic impacts within the sector. But most experts agree that large investments are required to succeed in the low carbon transition and could represent large opportunities in terms of creating qualitative and local jobs within the power sector.

D. Transport Sector

In our analysis, the transport sector is split into two subsectors. The first subsector is transportation services, including all public and private companies (NMBS/SNCB, De Lijn, TEC, STIB/MIVB, taxis, airlines, etc.), as well as logistic services. The second subsector encompasses the sectors that are manufacturing, distributing and maintaining transport vehicles.

The models allow to analyse the effect on both subsectors separately:

Transportation services

The analysis focuses on the "rail and road transport services" sector, as modelled in HERMES. The CORE LOW CARBON scenario estimates a positive impact for the sector, with about 3000 additional jobs created and additional € 1.3 billion of added value in 2030.

The main drivers behind the evolution of employment, and the value added in the sub-sector, are formed by the boosting effect on overall economic activity as entailed through the extra demand push (see Section III.A for more details), the modal shift and the production price reductions, as a result of the energy efficiency gains which also stem from low carbon measures and actions in the sector.

Manufacturing, distribution and maintenance of transport vehicles

While it does capture them, the HERMES model does not detail the impacts on sectors such as manufacturing, distribution and the maintenance of transport vehicles. Such analysis is performed in OPEERA-IO, which has the relevant granularity needed in order to test specific sectoral impacts of changes within the overall transport vehicles' value chain.

The different low carbon scenarios lead to very different impacts on the total number and type of vehicles that will be driven in the coming decades. Scenarios that focus on behavioural changes (such as the BEHAVIOUR or -95% GHG low carbon scenarios) assume a large decrease in car ownership. The behavioural measures and actions impact upon the overall value chain of the transport vehicles (mainly manufacturing industries, distribution services and maintenance services) and might lead to lower job creation rates if the money saved on cars or fuel is not reinvested in other local products or services.

Results from the BEHAVIOUR scenario, in which lower mobility demand and/or a higher use of collective and public transportation is assumed, show a reduction in the number of jobs, compared to the REFERENCE scenario. The manufacture, distribution and maintenance of collective vehicles would not compensate for the decrease of activity related to the distribution and maintenance of individual, internal combustion engine cars.

The more technological scenarios assume that the number of private cars will remain more or less constant, taking into account that the share of low carbon vehicles in the fleet will increase. In the TECHNOLOGY scenario, additional jobs are created compared to the REFERENCE scenario. This is explained by the fact that even though the number of vehicles is assumed to be stable, low carbon vehicles remain somewhat more expensive up to 2030, boosting value creation within the value chain. Maintaining these vehicles also requires new skills and competences, representing an opportunity for a shift in employment opportunities.

Figure 11 below highlights the potential for job creation arising from low carbon measures and actions related to both individual and collective low carbon vehicles within the overall transport vehicle value chain.

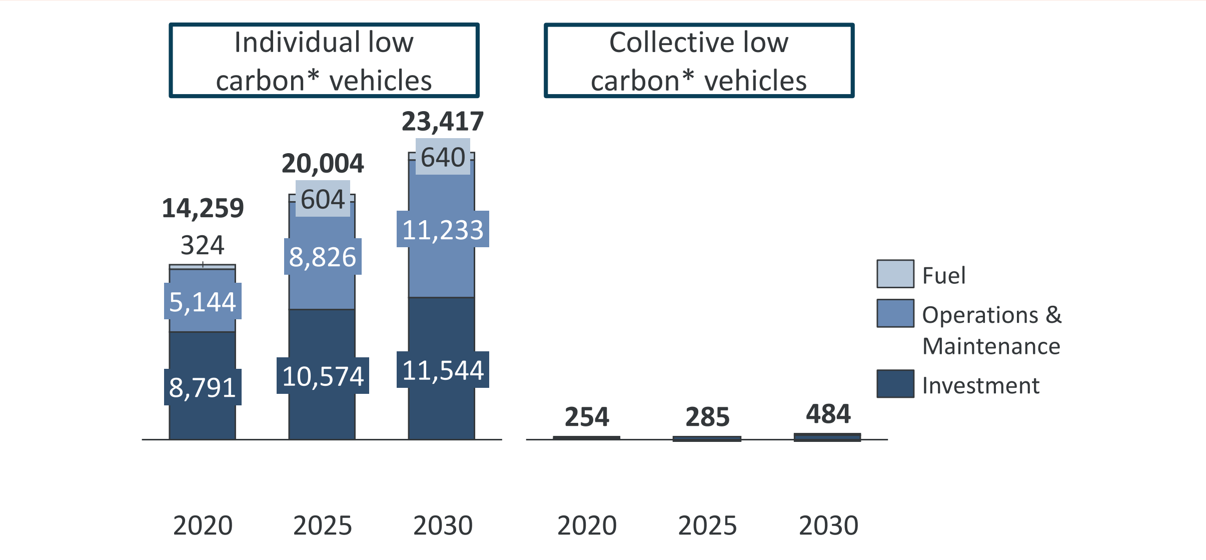


Figure 11. Jobs created by transport measures and actions, in jobs in that year, CORE LOW CARBON wrt REFERENCE scenario, OPEERA-IO[34]

Different opportunities within the transport sectors: view of experts

Innovations in new technologies or new business models in the transport sector could represent large economic opportunities.

Experts highlighted the emergence of innovations such as autonomous or connected vehicles that could play a role in increasing the energy efficiency of transport while further decreasing the congestion issues. Smart electric vehicles could also play a role in the power sector, offering for example new balancing services for grid operators.

Experts have also highlighted the potential of new business models: the development in which new collective, flexible, shared and smart transport services such as car sharing or mobility are offered as a service is something already undergoing rapid growth.

Transport infrastructures will need to evolve with the low carbon transition. Though the investments in electric and collective mobility vehicles are taken into consideration in the study, no account is taken of the potentially decreasing investment needs in respect of road infrastructure (when a decrease of mobility demand is assumed). It would be interesting to compare the economic impact of investments in traditional road infrastructure with investments in low carbon infrastructures.

34 Annex 4 includes details on value chain assumptions and Annex 1 includes details on sectoral results.

E. Agriculture Sector

The agriculture sector is not fully represented in the macroeconomic models used to perform the present study. The analysis is therefore limited to a literature review and an exchange of views with experts and stakeholders. Results are presented in the text box below.

Different opportunities for the sector: view of experts

1. Opportunities to reduce GHG emissions within the agricultural sector

According to most experts, technical options for reducing GHG emissions within the sector could be even more important than those analysed in the study on "Scenarios for a low carbon Belgium by 2050". Lots of efforts have already been made and initiatives should be pursued to favour technical innovation. Technical options could provide solutions with a view to developing different agricultural models and an economically and environmentally sustainable food supply chain.

In the technical study behavioural options have been stressed as important levers for achieving reductions in GHG emissions. Scientific literature highlights how the current trend towards a lower demand for animal proteins would play an important role in decreasing GHG emissions, while also leading to a positive health effect. Further analysis could help in understanding the impacts on the overall economy arising from a protein transition oriented towards a more sustainable food and agricultural system.

Changes in diets in Belgium might decrease demand for some agricultural products. However, if production is significantly more competitive in Belgium than abroad, current production levels could be maintained in Belgium.

2. Opportunities to develop new initiatives within the agricultural sector

Experts highlight the potential of initiatives designed to limit food waste and support the circular economy. They also highlight the importance of developing initiatives for the entire food supply chain (from producers to customers) to effectively tackle the sustainability challenge. All of these initiatives could have important and local economic development potential, because they create new business opportunities, support innovation, and reduce costs.

V. RESULTS: OTHER IMPACTS

Macroeconomic models do not enable the assessment of potentially important links between low carbon policies and other policies or between other social or environmental objectives such as public health and air pollution.

The literature on these matters highlights two types of impacts that are not taken into account in conventional analyses based on macroeconomic modelling.

1. Potential impacts of climate non-action

Macroeconomic models include neither the negative impacts of climate change nor the potential impacts of climate non-action.

The IPPC[35] highlights the potential costs of damage arising from climate change, this includes from floods, water scarcity, extreme heat events, wildfires or other events. The OECD[36] also highlights the potentially negative impacts of climate change on economic growth, such as productivity changes in various sectors, damages to capital, changes in demand for healthcare or energy, etc.

An evaluation of the potential costs related to these impacts is discussed in the literature. However, uncertainties and methodological limitations still remain important elements.

2. Potential co-benefits of climate action

Models also fail to take into account potential "co-benefits" that the implementation of low carbon policies and measures would entail. The main co-benefits of climate action described in the literature are briefly presented below with a high-level assessment of the economic impact at stake (in GDP equivalent, which does not necessary means the GDP is impacted).

Air pollution

Air pollution is responsible for large impacts on health and is mainly caused by the use of fossil fuels in transport, power generation or the heating of buildings. The OECD estimates that the cost of air pollution caused by transportation amounts to ~ 4% of Belgium's GDP[37]. Reduction of air pollution is a major public health challenge that can also be tackled through adequate climate change policies.

Congestion and road accidents

The increase of traffic congestion as well as road accidents is costly for the overall society as it affects drivers' health, is responsible for a waste of energy and time, etc. In Belgium, the cost of congestion and road accidents is esti-

35 IPCC (2007), "Fourth Assessment Report", Chapter 5.7.
36 OECD (2015), "The Economic Consequences of Climate Change".
37 OECD (2014), "The Cost of Air Pollution, Health Impacts of Road Transport".

mated to be equivalent to 3 to 4% of the GDP[38]. Climate policy is expected to encourage a shift towards collective transport, as well as a decrease in the mobility demand. These developments would lead to a reduction of the number of cars on the road and therefore directly reduce the cost of congestion and road accidents.

Living environment

The weak level of insulation and ventilation of houses has an impact on the health and the comfort of the inhabitants. The International Energy Agency estimates that the impact of a sub-optimal living environment would be equivalent to 1 – 2% of EU GDP[39]. Climate policy is expected to accelerate the rate of retrofitting, to a higher standard of energy efficiency, which would bring large benefits for the living environment.

Healthy diet

An unbalanced diet is a source of diseases that has an important impact on the health system. The literature does not assess the impact for Belgium but as an example, the cost for the UK health system has been evaluated to be equivalent to as much as 6% of the UK GDP[40]. Climate policy is expected to encourage a shift from a diet based mainly on animal proteins (meat) towards a diet consisting of a mix of sustainably produced animal and vegetal proteins, which would have important health benefits.

38 van Essen et al. (2011), "External costs of transport", Report commissioned by the International Union of Railways, November and Christidis et al. (2012), "Measuring Road Congestion", JRC scientific and policy reports, European Commission Joint Research Centre, Institute for Prospective Technological Studies.

39 IEA (2014), "Capturing the multiple benefits of energy efficiency".

40 Scarborough et al. (2012), "Modelling the health impact of environmentally sustainable dietary scenarios in the UK", European Journal of Clinical Nutrition, vol. 66, pp. 710–715.

VI. CONCLUSION

The aim of this study is to answer the following question: what are the likely macro-economic impacts of the low carbon transition in Belgium? To address the complexity of that question, an innovative methodology has been developed based on two different macroeconomic models complemented by a techno-economic model and consultation with experts and stakeholders. The analysis focuses on the impact on growth, employment, competitiveness and co-benefits. Four key conclusions emerge from the study.

Economic activity: a drastic reduction of GHG emissions is compatible with an economic growth level that is comparable to the level of – but different in terms of content from – the growth observed in a business-as-usual scenario.

Modelling results indicate that emission reduction measures and actions allowing the following of a low carbon pathway do not substantially affect the Gross Domestic Product growth level. The Hermes model even shows that a GDP rise of around 2% – on top of the reference level – could be achieved in 2030 in Belgium if adequate policies are adopted.

The main operating mechanisms are the as follows. The low carbon nature of investments makes it possible to reduce the different actors' fuel expenses. Subsequently, the increased private and public investment level contributes to the revival of economic activity in the different sectors. Finally, given the openness of the Belgian economy, the stimulating effect on activity is enhanced by the adoption of low carbon policies by other countries, at both the European and international level. All this leads to an improvement of the companies' operating surplus and to an enhancement of the households' purchasing power.

Certain emission reduction measures and actions lead to the adoption of different lifestyles in the field of individual mobility, habitat, food and consumption habits, etc., from those considered in an unchanged policy scenario. The growth content of a low carbon economy is indeed potentially quite different from the growth content of an economy that doesn't undergo such a transition.

Employment: towards net job creation, with mixed impacts at sector level

Compared to an unchanged policy scenario, the transition can lead to a net employment growth in Belgium, amounting to approximately 80,000 jobs in 2030.

As the structure of the investments in a low carbon energy system is different to that of an unchanged policy scenario, the various economic sectors are impacted in different ways. Also, since the largest number of direct new jobs is expected in the construction sector, the issue of the posting of workers in this sector deserves particular attention. A significant number of jobs would be created in industry as well, including in the intermediate goods sector. However, the transport sector would be affected in an asymmetric way: job losses related to decreased demand for private vehicle maintenance would be mitigated by the positive effects of the economic activity in the sector, for example in the deployment of services related to collective transport. Finally, half of the employment creation would be indirect, showing a significant rise in the services sector.

The carbon price policy also has an impact on employment. Public revenues resulting from the implementation of a carbon price are substantial, totalling about 3.5 billion Euros in the year 2030 under a core scenario. Any tax shift intended to spend all or part of this revenue in order to lower labour costs, would favour both employment and growth.

Competitiveness: a net gain for industrial sectors provided that the international context and the specificity of certain companies and value chains are adequately taken into account when defining policies and measures.

At the macroeconomic level, the increase of energy prices has a moderate effect on production costs due to the increase in energy efficiency. In 2030, the latter will make it possible to halve the deficit of the energy balance in Belgium, corresponding to a gain of about 2 GDP percentage points. This constitutes an advantage for European industries in compared to their international competitors. Moreover, the revival of economic activity stimulates international trade. In Belgium, the increase in imports mainly concerns intermediate goods and equipment goods.

However, we should pay attention to the microeconomic components of competitiveness. Indeed, the value chains are important in a whole series of industries, meaning that every cascading impact should be evaluated and anticipated. Moreover, the decreasing demand for certain products (e.g. from the refining or the agriculture and food industries) does not necessarily mean that the domestic production will be proportionally affected: the Belgian sectors which are among the most competitive within the Union, could increase their export, maintain their production level and thus increase their market share. These elements advocate for the implementation of policies and measures guaranteeing that European and international companies will be treated in the most homogeneous way possible.

Co-benefits: emission reduction policies may lead to considerable advantages in many other fields.

GHG emission reduction policies and measures can also have an impact on a series of other indicators and even indirectly on growth itself. Besides their contribution to the reduction of damages caused by climate change, they will also allow for the avoidance of air pollutant emissions of which the economic cost is generally estimated to be around 4% of the Belgian GDP. The traffic congestion and the number of traffic accidents would also largely benefit from mitigation policies in the transport sector. The increased comfort of indoor habitats and the decreasing consumption of animal proteins also entail important health benefits, besides the significant improvement of energy security and the economy's higher resilience to systemic risks.

VII. ANNEXES

The following Annexes are available online at the following address: www.climatechange.be/2050 (see Scenario Analysis):

- Annex 1: Detailed results
- Annex 2: HERMES modelling
- Annex 3: GEIM modelling
- Annex 4: OPEERA-IO modelling
- Annex 5: Literature review

TOWARDS A
LOW CARBON SOCIETY