Scenarios for a Low Carbon Belgium by 2050

Summary of the findings

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TOWARDS A
LOW CARBON SOCIETY

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Foreword

We are committed to reducing our greenhouse gas emissions by 80 to 95% by 2050 relative to 1990. The route to a 'low carbon society' in 2050 will require substantial changes across a wide range of sectors and across many aspects of our lives. We have the opportunity to build that future.

Despite the difficulties in looking so far ahead, a successful low carbon transition requires a clear direction and early action. Investors and consumers require confidence to act, large building and infrastructure projects require long term planning, behaviours change gradually and new technology developments take time to reach commercial deployment. Time is shorter than it may seem and the pace of change has to increase drastically: significant decisions need to be taken in the coming decade, with some of them being clear 'no regrets'.

We will need to achieve these emissions reductions and realise a just transition while at the same time securing energy supply and safeguarding, even enhancing, the competiveness of our industry. The challenge is not limited to Europe: countries all over the world are undertaking their low carbon transition and it is clear that the direction that other nations are taking will affect the opportunities and the risks for Belgium. In any case, we must grasp the benefits offered by the transition: enhanced innovation, green jobs, a reduced energy bill and lower health impacts through reduced air pollution, to name a few.

We welcome this study realised by Climact and VITO. It shows that various transition pathways allow us to reach the necessary reductions. The exercise is not about choosing a specific pathway towards 2050. But this study does give us an understanding of where the 'good bet' actions lie and of the timing of necessary decisions.

This analysis indicates that a low carbon society can even lead to lower total system costs, as additional investment expenditures will be compensated by reduced fuel expenses. Given the inherent uncertainty in predicting the likely price of fossil fuels over forty years, the low carbon transition reduces the exposure of our society to the risk of high fossil fuel prices.

Shifting towards a low carbon society will require the consent and participation of citizens. It will also require to innovate and to develop new thinking in, for instance, governance and financing structures.

We will continue to investigate the complementary questions raised by this work. A web interface is also provided that allows all stakeholders and citizens to access the study and to build their own low carbon scenarios.

Roland Moreau
Director-general Environment
Federal Public Service Health, Food Chain Safety and Environment

Melchior Wathelet
State Secretary for the Environment

A. The low carbon transition challenge

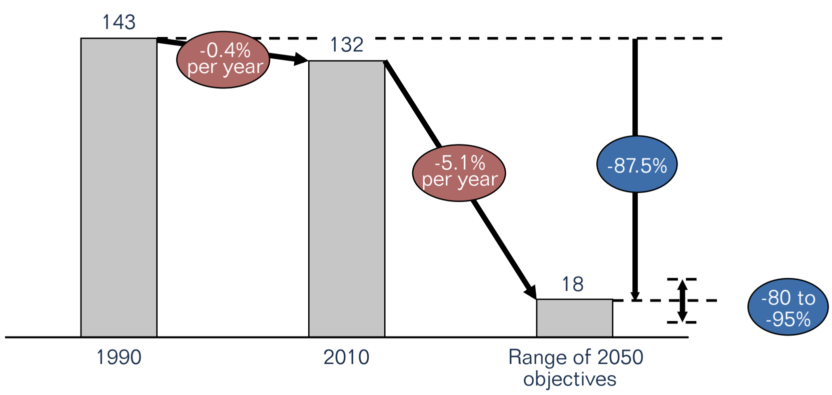
At the Cancún Climate Change Conference in 2010, all countries have decided to limit the rise in global average temperature to maximum 2°C above pre-industrial levels. At the request of the European Union, they also agreed that developed countries should establish 'Low Carbon Development Strategies' (LCDS).

In order to reach the 2°C target, deep cuts in greenhouse gas emissions are needed, between 80-95% by 2050 in developed countries with respect to emission levels in 1990. The European Union already endorsed such an emission reduction objective and it has been working towards its implementation ever since. The EU's Low Carbon Economy roadmap, accompanied by the Energy and Transport roadmaps, are important contributions in that respect as they show possible pathways of a low carbon transition at the European level.

Members States must actively prepare the transition and honour their commitment to implement national LCDS. Several of them are already far advanced in the design and implementation of their long term low carbon strategy. Furthermore, some important steps are being made at the regional or local levels. Several industrial sectors have also developed their sectoral low carbon roadmaps towards 2050.

The purpose of this analysis is to launch a discussion on a low carbon transition in Belgium in order to prepare a LCDS at national level. It is intended to explore possible pathways and some important techno-economic implications of significant reductions in greenhouse gas (GHG) emissions, such as the evolution of primary energy demand, the level of GHG emissions by sector, the evolution of the energy mix, including the role of various renewable energy sources and the investment and operating costs associated with each scenario. A significant increase in the yearly pace of GHG emissions reduction is required over the coming decades to achieve an 80-95% GHG reduction as illustrated in Figure 1.

'Scenarios for a low carbon Belgium by 2050' is the centrepiece of the '2050 Low Carbon Belgium' project. It is fully in line with the long term vision on sustainable development of the federal government, which foresees, *inter alia*, a reduction of greenhouse gas emissions by at least 80-95% by 2050 with respect to 1990 on the Belgian territory. The report of the study and a web-tool that allows you to build and analyse your own pathway to a low carbon future, as well as other useful materials can be found at www.climatechange.be/2050.



Source: Belgium GHG emissions inventory, Climact

Figure 1. Historical evolution of Belgian GHG emissions (in $MtCO_2e$ per year) and range of 2050 objectives.

B. Pathways analysis based on an open 'expert-driven' model

The study shows that various low carbon pathways are possible and societal choices are required to properly support the transition to a low carbon society. Given the uncertainties arising from a horizon as long term as 2050, a scenario approach is used to analyse a variety of potential outcomes under various assumptions.

As a first step, a sectoral approach was used to understand what types and levels of change are technically possible in each area. For each emission reduction lever identified, a range of ambition levels was built to ensure that a wide range of potential futures could be tested.

These levers and the possible ambition levels related to them underpin the Belgian version of the OPEERA[1] model which was developed to construct possible scenarios to 2050. OPEERA is an 'Expert-Driven' model developed with the Department Energy and Climate Change of the United Kingdom (DECC).

In addition to a thorough literature review, the study builds extensively on thematic workshops and intensive discussions with a large number of experts in business, NGOs, technical fields, and academics. More than a hundred experts were consulted on several occasions, especially with respect to the ambition levels feasible for each reduction lever. Their contributions are gratefully acknowledged.[2] More concretely, the main GHG emission reduction levers and the main activity parameters have been identified and modelled in each sector. Four possible ambition levels have been defined for each lever:

– The first level implies a minimum effort, corresponding to the implementation of existing regulation extrapolated with similar trends and no specific additional efforts.

– The fourth level implies a maximum physical or technical potential, based on key technical and spatial constraints. This fourth level represents a major challenge for society, but not necessarily a complete shift of our consumption and production patterns.

– The second and third levels are intermediary levels between these two extremes.

According to some stakeholders, further lifestyle changes are possible beyond level 4, resulting in even higher ambition levels. These include, for instance, changes related to transport (e.g. further reductions in personal transport), buildings (e.g. new housing solutions, adequate insulation and proper temperature management) or consumption patterns (e.g. eating less meat).

Many levers are of a technological nature. This study adopts a conservative approach in the sense that, except for Carbon Capture and Storage (CCS) and deep geothermal energy sources, only currently available technologies are modelled. Future breakthrough technologies would therefore further ease the low carbon transition.

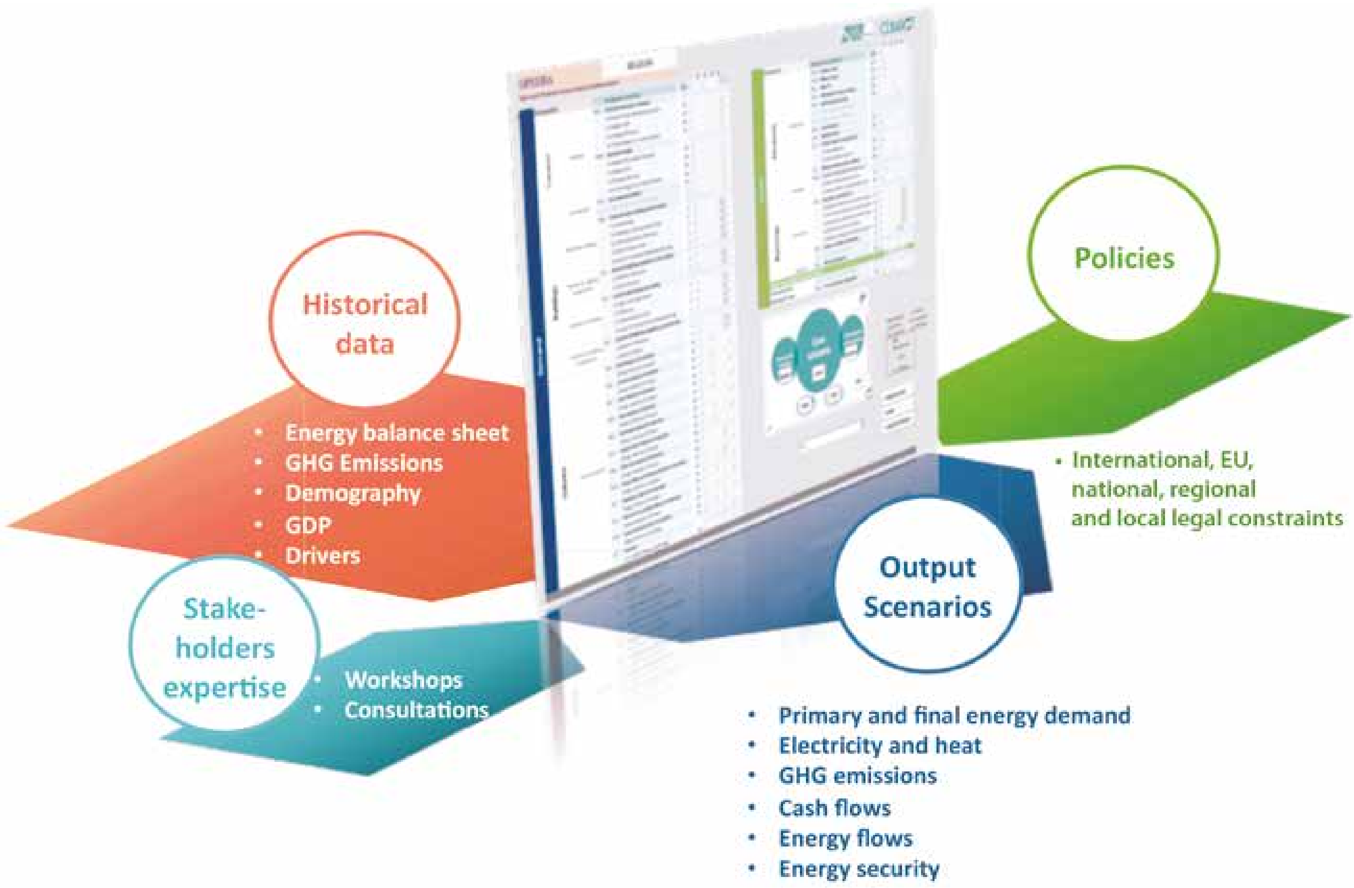
An interactive web-tool, based on the OPEERA model is available at www.climatechange.be/2050.

Pre-recorded scenarios, including the five scenarios developed in the study, are available. By simply changing the ambition level of one or several levers, one can build other possible scenarios and assess their impact on greenhouse gas emissions and on a series of key variables.

This series of impacts, however, does not give a complete picture of all impacts of a low carbon transition. For instance, competitiveness issues are not explicitly dealt with. The analysis implicitly assumes that either all countries around the world do engage in comparable efforts or that the appropriate measures are taken at the European and national levels to prevent any risk of carbon

1 OPEERA stands for Open-source Emissions and Energy Roadmap Analysis.

2 The responsibility of the analysis however lies with the authors of the study and the experts consulted do not necessarily endorse the analyses or the conclusions of the study.



The OPEERA model integrates expertise from stakeholders, historical data and policy information and was developed to construct possible pathways to 2050.

leakage. Furthermore, computing external costs and benefits of the scenarios, such as reduced congestion or air pollution, fall beyond the scope of this study. Hence, this study must be supplemented by further analyses.

C. A set of 5 low carbon scenarios

Five decarbonisation scenarios are developed (see Figure 2), complemented by some specific analyses or sensitivities. In each scenario, it has been assumed that industrial activity levels are similar to those under a 'business-as-usual' situation.[3] In other words, none of the five scenarios assumes that industrial production can be used as a lever for reducing emissions in the industry sector. On the contrary, the analysis implicitly suggests that the low carbon transition is compatible with a growing industry.

A REFERENCE scenario

The 'REFERENCE' scenario is built as a reference against which the five decarbonisation scenarios are evaluated. It is consistent with current legislation and achievement of the 2020 objectives of the European climate and energy package. However, no targets are specified after 2020: current trends in the various sectors are extended to 2050 and the levers are set at the first ambition level.

Three decarbonisation scenarios leading to 80% reduction in GHG emissions by 2050 with respect to emission levels in 1990 are developed, the CORE, BEHAVIOUR and TECHNOLOGY scenarios.

3 This is not the case for the sectors where the low carbon transition impacts the activities, such as a stimulation of the glass and bricks industries by stepping up building renovation or a reduction in oil refinery activities due to lower consumption of fossil fuels.

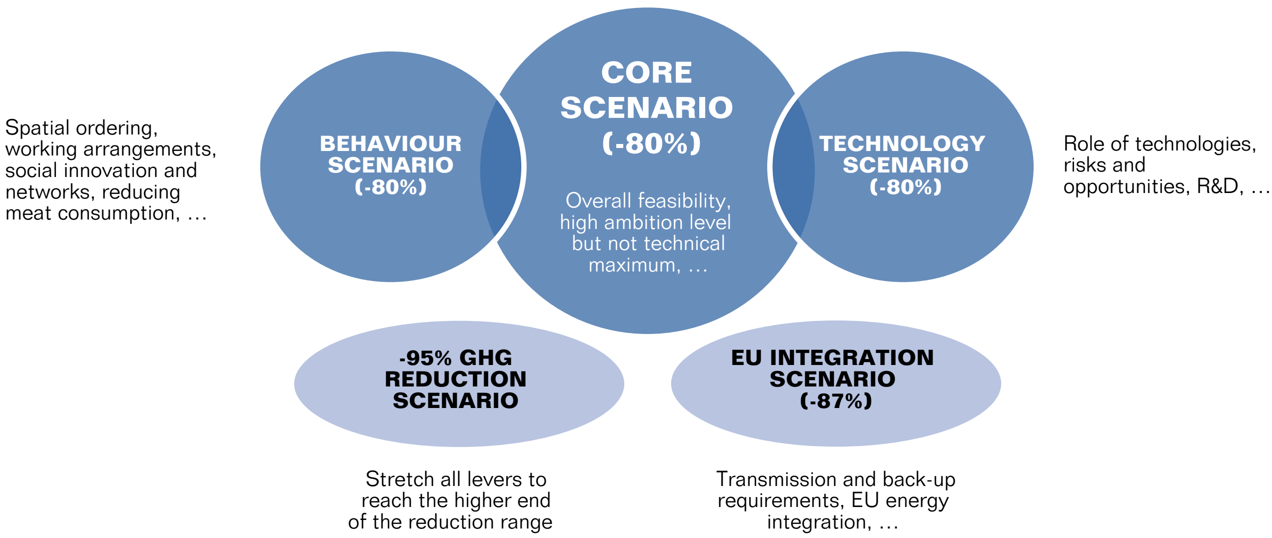


Figure 2. A set of 5 low carbon scenarios for Belgium to reach an 80-95% GHG emissions reduction.

The CORE scenario

The 'CORE' scenario strives to put all levers to work while not pushing them to their maximum. In practice, this scenario corresponds to the implementation of all levers around their 3rd level of ambition.

The two other scenarios leading to an 80% reduction of GHG are developed around this 'CORE' scenario.

The BEHAVIOUR scenario

A 'BEHAVIOUR and SOCIETAL ORGANIZATION' scenario (shortened to the BEHAVIOUR scenario) puts the emphasis on emission reduction possibilities through ambitious changes in behaviour and lifestyles, such as a lower transport demand, a drop in meat consumption, heating and cooling in houses, etc.

It implicitly assumes that all necessary cultural, structural, organisational and institutional changes needed to make possible this type of behavioural change are implemented (e.g., more investment in public transport, more working at home, climate change awareness raising, etc.).

To keep it short, we refer to all these changes as 'behavioural', which does not imply that the changes in this scenario are assumed to be the result of pure voluntarism. Levers related to such changes are set at their 4th level of ambition, which allows reducing the reliance on technological levers with respect to the 'CORE' scenario.

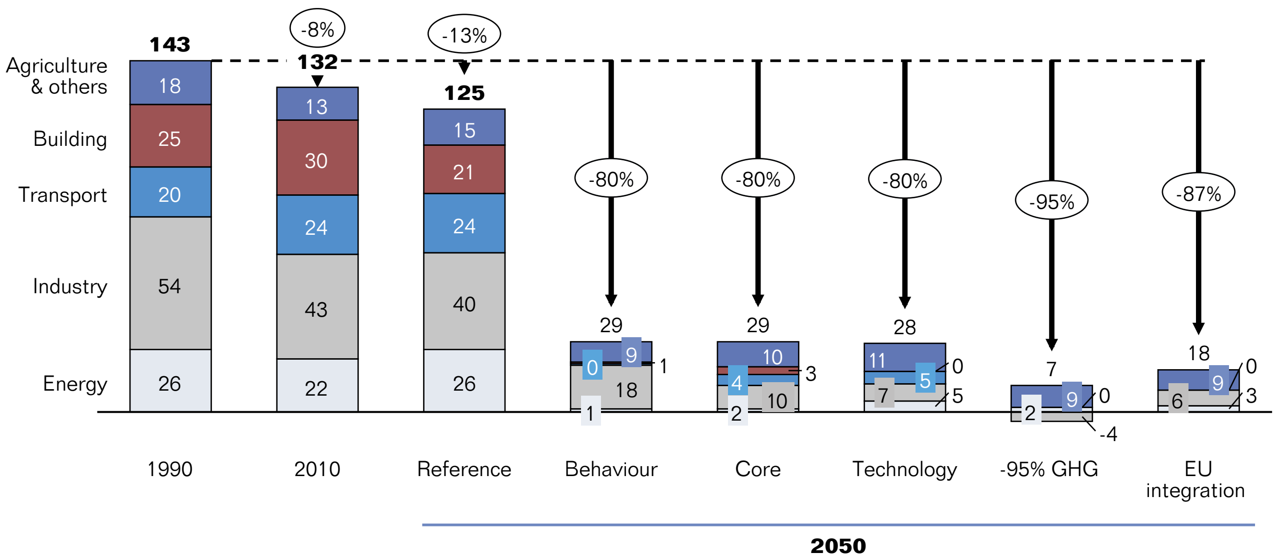


Figure 3. Comparison of the GHG emission reductions in all scenarios (emissions in $MtCO_2e$ per year).

The TECHNOLOGY scenario

In contrast, a 'TECHNOLOGY' scenario focuses on technological evolutions such as electrification levels in the transport and buildings sectors, process changes in industry, etc. Such levers are set at level 4. Behavioural changes are then less ambitious than in the 'CORE' scenario.

The purpose is to illustrate how far strong deployment of key technologies can lead us towards our decarbonisation goals. With lower changes on the behaviour side, it is necessary to expand the use of technological abatement options to achieve the same reduction levels. Energy demand is higher and requires higher deployment of supply technologies, including CCS in the power sector.

The 95% GHG REDUCTION scenario

A fourth scenario, called '95% GHG REDUCTION', reflects the highest ambition in the GHG emission reduction target range. It is built to test the technical feasibility of a stronger GHG reduction by the year 2050. The technical boundaries of the various levers are set at level 4 to explore the maximum potential and resilience of all decarbonisation options.

It represents a major challenge for society, but not necessarily a complete paradigm shift (e.g. the industry production trajectories have been kept at the same level as in the REFERENCE scenario, see above).

It implies significant efforts from all actors in the society as lifestyles changes need to be combined with large technical GHG reduction solutions including CCS. In this scenario all demand-side levers are set at their technical potential (level 4).

The EU INTEGRATION scenario

Finally, a fifth scenario called 'EU INTEGRATION', which reaches an 87% GHG reduction, focuses on the supply side, namely by assuming high intermittency levels combined with tighter European grid integration, higher imports of electricity and larger amounts of back-up plants. This scenario is based on the assumption that European electricity grids are strongly developed and that European energy markets are highly integrated and share infrastructure.

This scenario leads to an energy system largely based on renewable primary energy sources. Its purpose is to derive learning on issues that include demand management, transmission and back-up requirements. Behavioural demand-side levers are set at levels similar to those selected in the REFERENCE scenario. On the supply-side, levers are set at a level that reflects the assumptions of the study 'Towards 100% renewable energy in Belgium by 2050' by VITO, the Federal Planning Bureau and ICEDD, which was published in December 2012.

Figure 3 illustrates the level of GHG emissions in each scenario. It is worth noting that agriculture constitutes a significant block of emissions in all scenarios in 2050. As for industry, it requires the use of CCS in four scenarios ('CORE', 'TECHNOLOGY', 'EU INTEGRATION' and '-95% GHG') and even CCS with biomass in one of them ('-95% GHG').

Implications of these scenarios at the sector level and overall messages on the low carbon transition in Belgium are presented hereafter.

The table on next page summarises the main indicators characterizing the scenarios in 2050.

	Units	Reference		Core		Behaviour		Technology		-95 % GHG		EU Integration	
GHG emissions wrt 2010 (1990)	%	**-6%**	**(-13%)**	**-78%**	**(-80%)**	**-78%**	**(-80%)**	**-79%**	**(-80%)**	**-95%**	**(-95%)**	**-86%**	**(-87%)**
Buildings[4]	%	-32%	(-17%)	-89%	(-87%)	-98%	(-98%)	-99%	(-99%)	-100%	(-100%)	-100%	(-100%)
Transport	%	-1%	(+18%)	-82%	(-79%)	-98%	(-98%)	-81%	(-77%)	-99%	(-99%)	-98%	(-98%)
Industry	%	-7%	(-27%)	-78%	(-82%)	-58%	(-67%)	-83%	(-86%)	-109%[5]	(-107%)[5]	-86%	(-89%)
Power	%	+12%	(-6%)	-98%	(-98%)	-98%	(-98%)	-86%	(-88%)	-96%	(-97%)	-96%	(-96%)
Agriculture & waste	%	+9%	(-19%)	-27%	(-46%)	-36%	(-52%)	-17%	(-38%)	-36%	(-52%)	-36%	(-52%)
Energy demand wrt 2010 (1990)	%	+17%	(+55%)	-35%	(-14%)	-45%	(-27%)	-29%	(-6%)	-53%	(-38%)	-39%	(-19%)
Biomass use	TWh	69		98		107		99		110		119	
Carbon Capture and Storage (CCS)	$MtCO_2e$	0.0		-9.4		0.0		-17.7		-14.3		-4.4	
Electricity													
Consumption in 2050	TWh	135		104		88		126		89		140	
Consumption wrt 2010 (1990)	%	+56%	(+128%)	+20%	(+76%)	+1%	(+48%)	+46%	(+114%)	+3%	(+51%)	+62%	(+137%)

4 Emissions are compared to actual 2010 figures which were particularly high due to a very cold year. The model uses an average numbre of degree-days leading to lower emissions in 2010.
5 Industry emissions reductions in the -95% GHG scenario (-109% / -107% GHG) are the result of a combination of CCS and biomass allowing industry to achieve negative GHG emissions while keeping the same industry trajectories as in the other scenarios. Alternatively, the -95% GHG scenario could be built with lower industry trajectories that would result in other GHG profiles.

Main indicators of the 5 scenarios in 2050.

D. Implications of the low carbon transition: findings at sector level

GHG emissions in Belgium have been allocated to five different sectors: transport, buildings, industry, agriculture and energy supply. The five main messages that emerge from the sectoral analysis are presented and described below, followed by another five overall findings for all sectors. Sensitivity analyses have been performed to guarantee the robustness of these findings.

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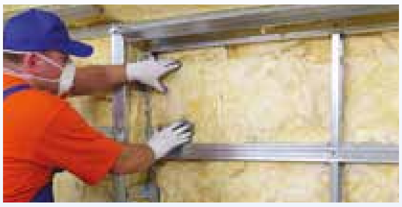
FINDING 1

In the transport sector, reduced mobility demand and electrification play a key role.

FINDING 2



In the buildings sector, the renovation rate of existing buildings must increase and fossil fuel heating systems must be replaced by environmental heating systems.

FINDING 3

In the industry sector, energy efficiency and process improvements will allow further emission reductions. International competition needs to be taken into account.

FINDING 4

In the agriculture sector the technical potential for reduction is relatively limited. Behavioural changes, such as eating less meat, can play an important role.

FINDING 5

The share of electricity in the energy mix must rise significantly and can be provided by renewables.

In the transport sector, reduced mobility demand and electrification play a key role.

FINDING 1

Transport is a sector with a large GHG reduction potential through combined efforts to both reduce transport demand and apply appropriate technologies. Various scenarios lead to drastic reductions in GHG emissions in the transport sector by 2050, from 77% below the 1990 level (in the TECHNOLOGY scenario) to 99% (in the -95% GHG scenario).

The volume of transport is reduced mainly through two behavioural levers: a reduced travel demand per person and a modal shift from cars to public transport or soft transport modes. Regarding freight transport, a modal shift from trucks to trains and boats is envisaged. Furthermore, a rise in occupancy rates means that fewer vehicles will be needed to meet the total travel demand.

Figure 4 compares the total passengers transport demand and its distribution per mode in the REFERENCE and the CORE scenarios. The significant increase in the REFERENCE scenario is due to the combination of a larger population with a higher travel demand per person. In the CORE scenario, the volume of total transport demand increases by only 4.1% compared to 2010 due to a lower travel demand per person. The shift towards alternative modes is such that in the CORE scenario car travel amounts to only 65% of total transport, in comparison with 77% in the REFERENCE scenario.

The low carbon transition implies an almost complete shift to electric transport by 2050: in the CORE scenario, 80% of the car fleet in 2050 is composed of plug-in hybrid, battery electric or fuel cell cars. This electrification of the sector makes it possible to increase the energy efficiency of transport as electric vehicles are more efficient than internal combustion engines. It is also coherent with an energy supply system that reduces GHG emissions through the introduction of renewable energy sources in electricity production (see finding 5).

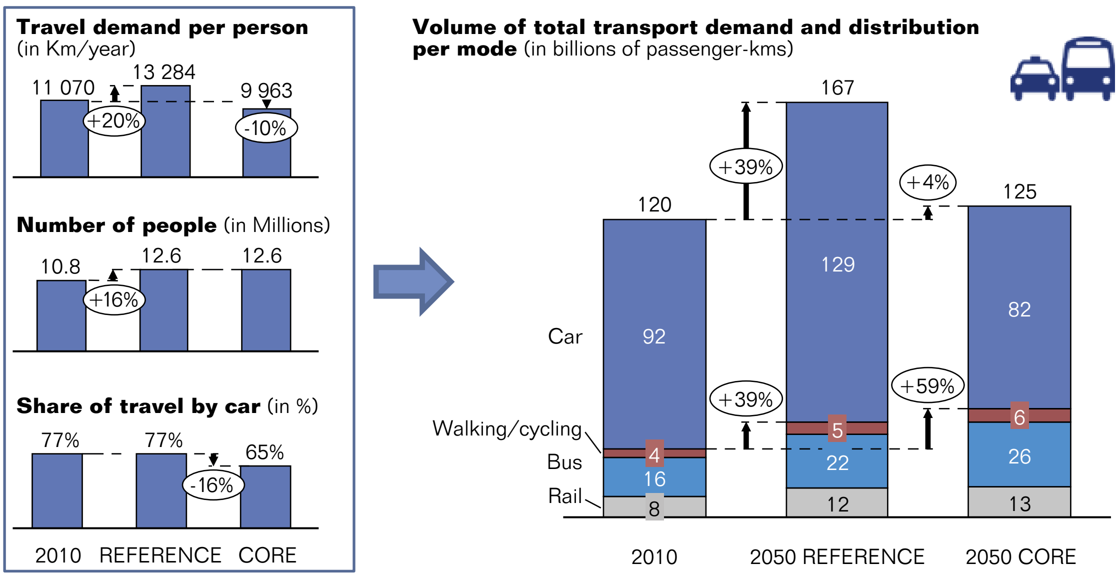


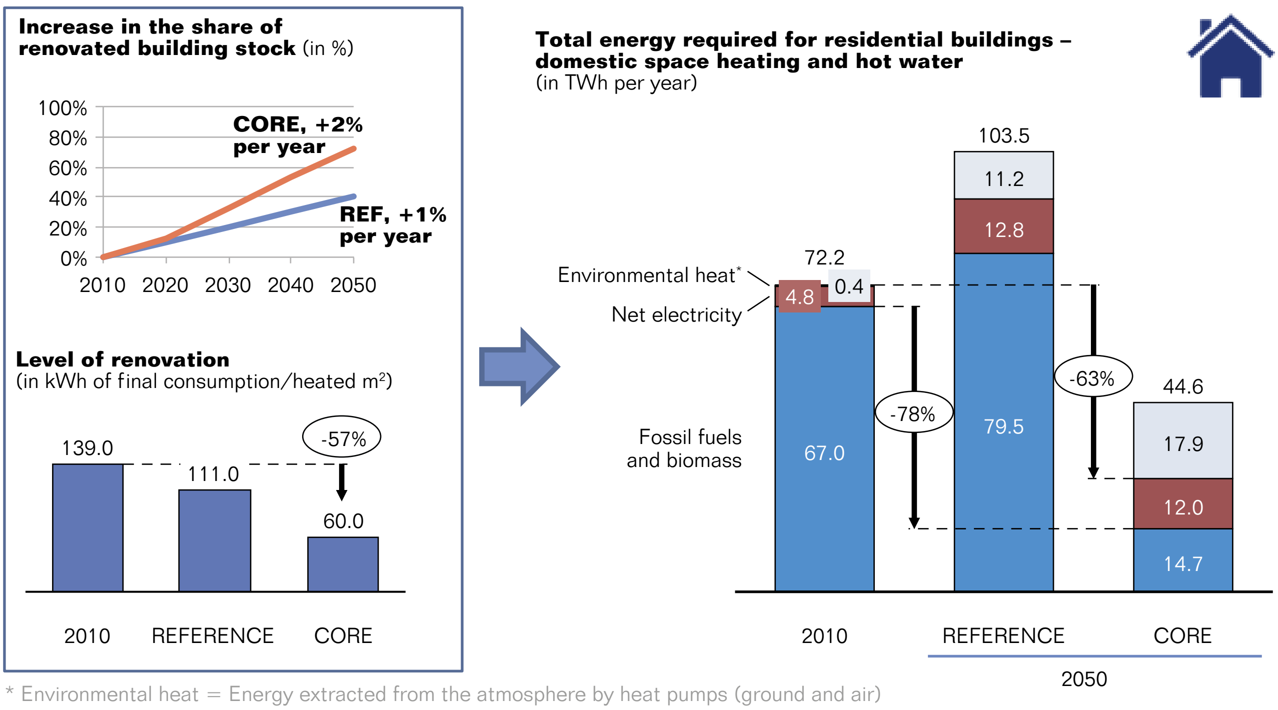
Figure 4. Impact of key drivers on total transport demand, and distribution of that demand across modes.

In the buildings sector, the renovation rate of existing buildings must increase and fossil fuel heating systems must be replaced by environmental heating systems.

FINDING 2

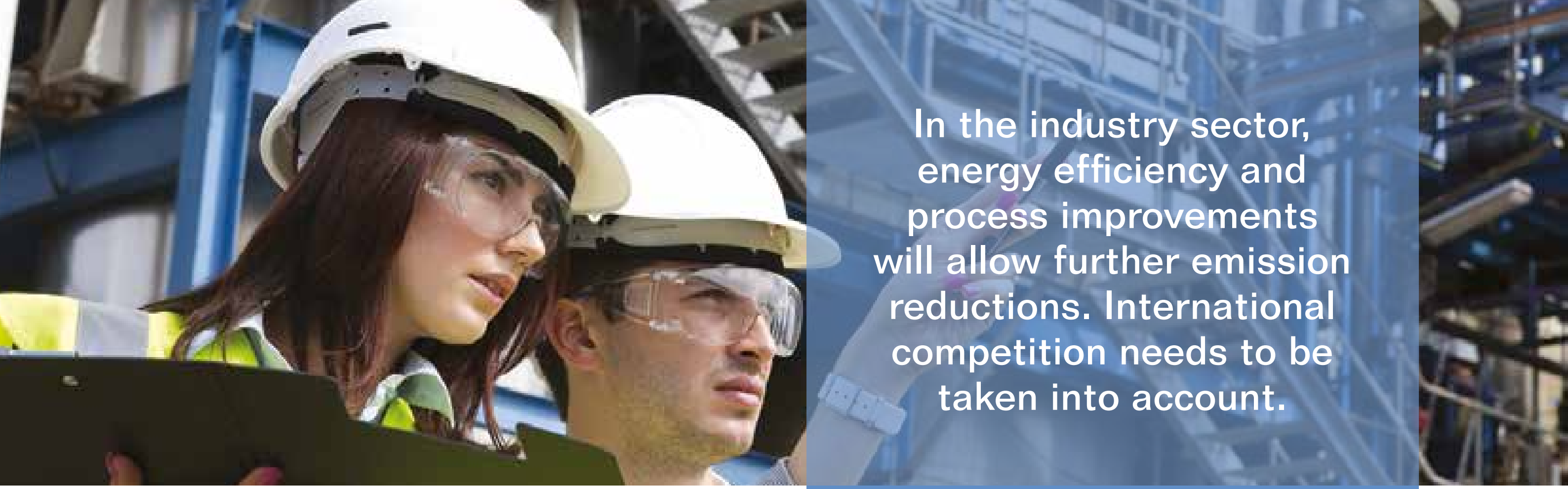
In the same way as transport, the buildings sector has a large potential for GHG reduction, through combined efforts to cut energy demand and apply appropriate technologies. The low carbon scenarios serve to abate GHG emissions in buildings by 87-100% by 2050 with respect to 1990.

Given the large share of old buildings in the Belgian stock, the rate and level of renovation will strongly impact the total GHG emissions by 2050. The rate and level of renovation double in the CORE scenario compared to the REFERENCE scenario. In addition to the renovation rate and level, the type of heating installations has a strong impact on final energy demand, as shown in Figure 5. Replacement of fossil fuel heating systems by environmental heating systems (mainly heat pumps) lowers final energy demand of buildings significantly.



* Environmental heat = Energy extracted from the atmosphere by heat pumps (ground and air) and from sun rays by solar thermal systems

Figure 5. Impact of key drivers on total buildings energy demand, and distribution of that demand across supply type.



In the industry sector, energy efficiency and process improvements will allow further emission reductions. International competition needs to be taken into account.

FINDING 3

While GHG emissions in transport and buildings rose between 1990 and 2010, industry emissions dropped sharply in the same period, partly due to an overall decline in activity levels. Continued energy efficiency and fuel switching can to some extent effect a further reduction of GHG emissions. However, in order to reach reductions in the order of 80% or more, new low carbon processes and the application of CCS will be necessary in many scenarios except in the BEHAVIOUR scenario where no CCS is required (see also finding 8).

GHG emissions in industry are lowered by 67% (in the BEHAVIOUR scenario) to 107%[6] (in the -95% GHG scenario) by 2050, with respect to 1990 GHG emission levels. Figure 6 shows the GHG evolution in the various sectors, according to the CORE scenario. With such large reductions in some sectors, much care must be taken to avoid any risks of carbon leakage: the reality of global competition must be recognized and the impact on competitiveness must be regularly assessed and monitored.

6 Emission reductions of more than 100% are the result of a combination of carbon capture and storage (CCS) and biomass.

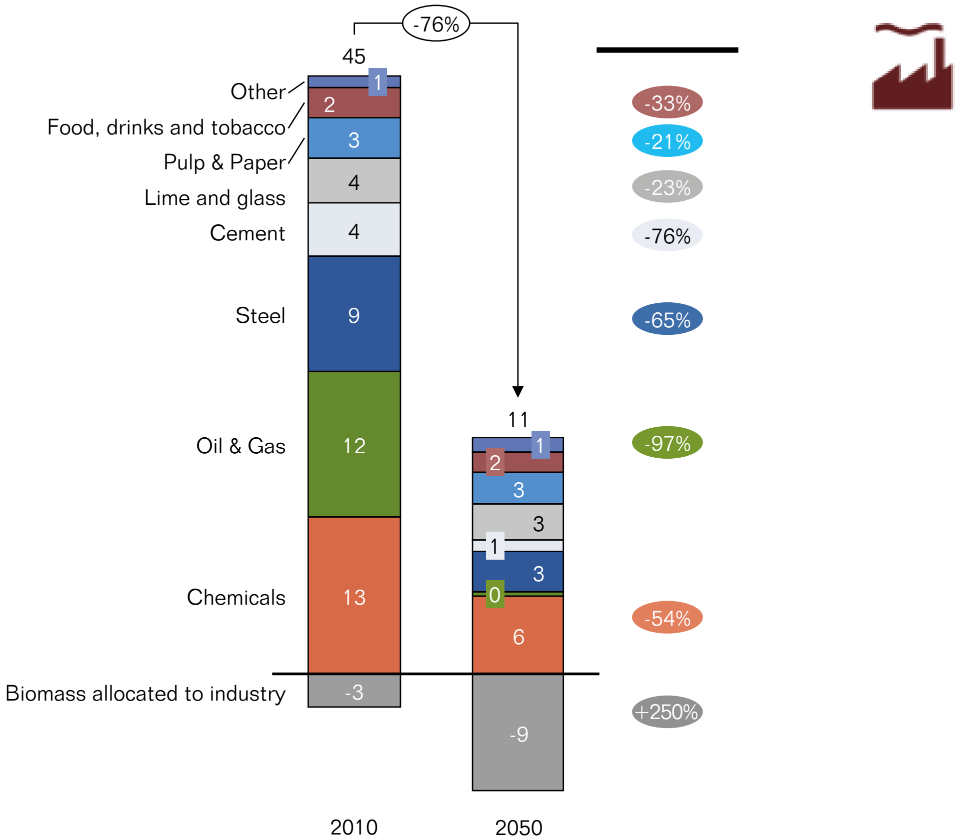


Figure 6. Evolution of industrial GHG emissions per sector in the CORE scenario (in $MtCO_2e$ per year).

In the agriculture sector the technical potential for reduction is relatively limited. Behavioural changes, such as eating less meat, can play an important role.

FINDING 4

Agriculture has a lower emission reduction potential than the other sectors. Various scenarios allow abating GHG emissions in agriculture by 38% (in the TECHNOLOGY scenario) to 52% (in the BEHAVIOUR, -95 GHG and EU INTEGRATION scenarios) by 2050, with respect to 1990.

As illustrated in Figure 7, a drop in meat consumption can have a very large impact on emissions, but requires an important shift in behaviour. Other technical measures exist but currently have a limited impact.

A continuation of the current production system, focusing on productivity gains and food production, has been assumed. However, a systemic approach is needed to attain a resilient and sustainable production system. Such an approach implies that trade-offs or choices have to be made. The agricultural sector not only has to focus on food and feed production but also on other functions, such as biodiversity, ecosystem services and bio energy production. The choices made will have an impact both on other economic sectors and throughout the food chain. Further research is needed to better evaluate the GHG reduction potential of the agricultural sector in such a context.

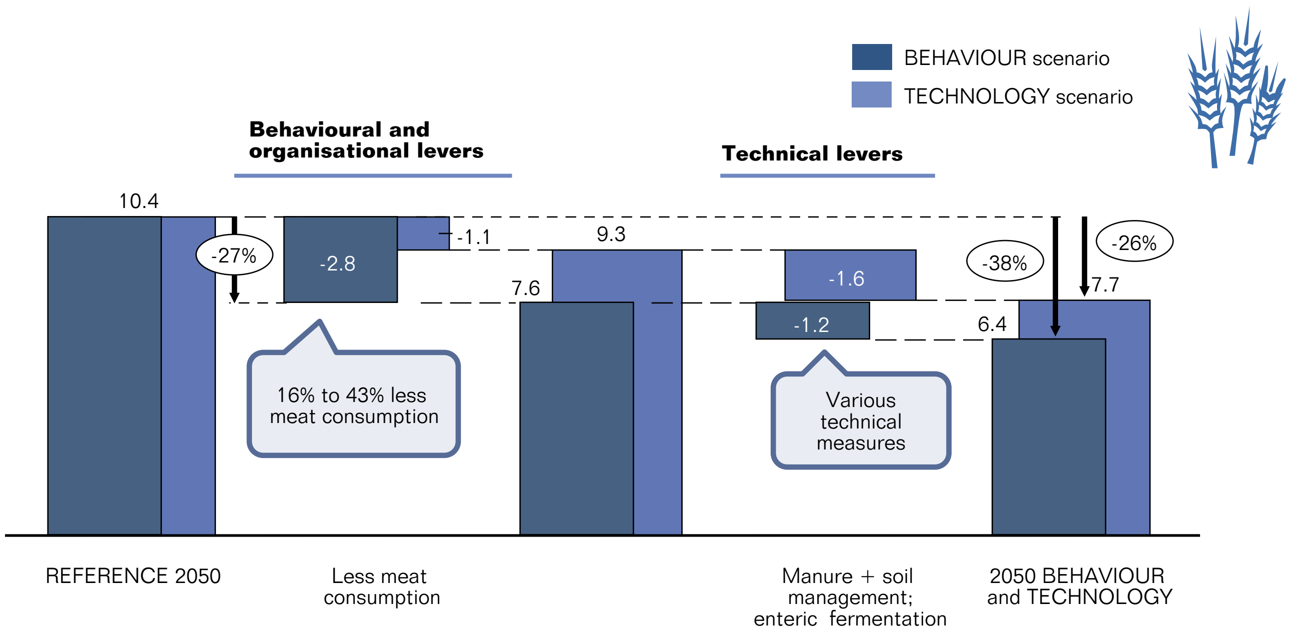


Figure 7. Impact of various levers on agriculture emissions (in MtCO_2e per year) in the BEHAVIOUR and the TECHNOLOGY scenarios.

The share of electricity in the energy mix must rise significantly and can be provided by renewables.

FINDING 5

Reductions in energy demand in all sectors translate into overall energy demand reductions (see finding 6 hereafter). The supply mix is also deemed to change to lead to lower GHG emissions. In all scenarios, the share of electricity in the supply mix increases. In the CORE scenario it increases from 20% in 2010 to 37% by 2050 (and to 52% in the EU INTEGRATION scenario). In absolute terms, total electricity demand rises above its 2010 level by 2050 in all scenarios, except in the BEHAVIOUR and the '-95% GHG' scenarios, where its level remains roughly constant over time.

The electricity sector must be almost completely decarbonised in order to support decarbonisation in other sectors: to achieve an 80-95% GHG reduction, emissions in the transport and buildings sectors have to be significantly reduced, partly through electrification of energy demand (see findings 1 and 2).

Figure 8 shows the level of electricity demand and the electricity production mix in 2050 for the various scenarios. By then, nuclear production will have disappeared as per latest federal legislation. Gas plants (without carbon capture and storage) are only found in the REFERENCE scenario and are key as an intermediary source of electricity between 2020 and 2040; they are replaced over time and potentially could be used further as back-up. Intermittent renewable energy sources (solar PV and wind) make up a significant share of the electricity production in 2050 (~50% in the CORE scenario). Non-intermittent renewable energy sources are also crucial, with biomass and geothermal complementing the mix and supporting grid stability along with back-up plants (see also finding 9).[7]

Lastly, in some of the scenarios, a certain amount of net electricity imports is assumed, with the EU INTEGRATION scenario having the highest imports (almost 10%), by assuming that the European market is fully integrated so that renewable energy that is produced elsewhere in a cheaper way, can be imported. Only in the TECHNOLOGY scenario is a small share of power generation with carbon capture and storage (CCS) assumed.

7 This would require an evolution of the electricity market to make these investments profitable.

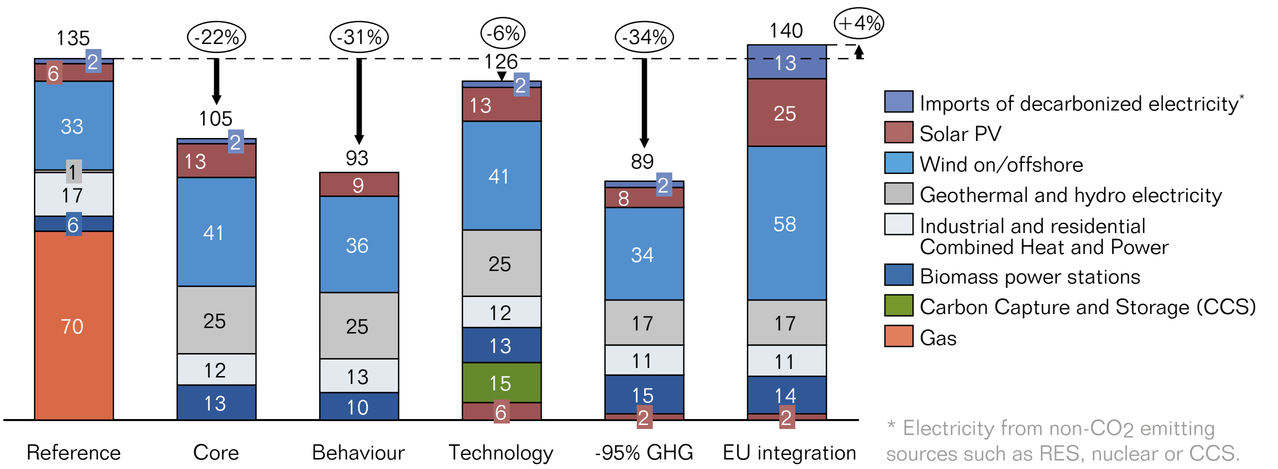


Figure 8. Electricity production mix by scenario (in TWh).

E. Implications of the low carbon transition: overall findings

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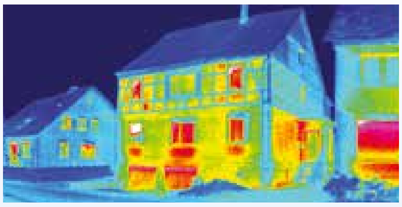
FINDING 6



Lowering energy demand is key.

FINDING 7

Fossil fuels are drastically reduced and renewables increase manifold.

FINDING 8

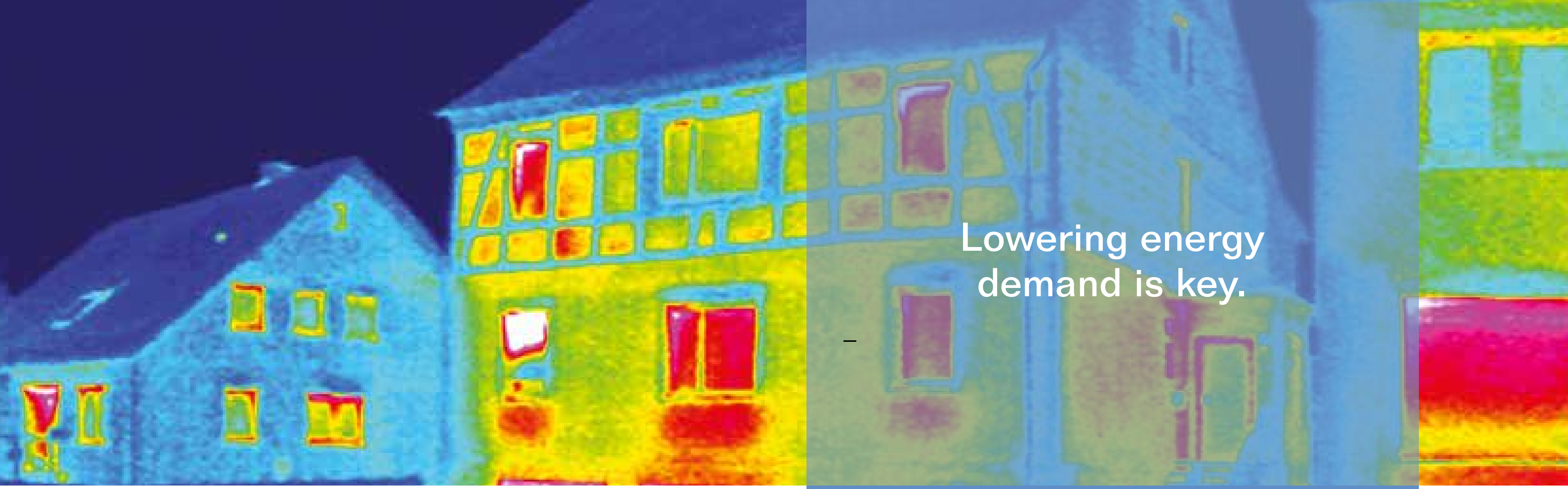
Sustainable biomass will likely be important for the low carbon transition. Carbon capture and storage could also play a significant role but raises concerns regarding its feasibility and potential risk.

FINDING 9

Intermittent energy sources will increase significantly. They are manageable but require large interconnection, back-up and demand-side management measures.

FINDING 10

The low carbon transition requires additional investment expenditures that are compensated by reduced fuel expenses.



FINDING 6

Many experts point to energy efficiency as the key driver for sustainable energy use. This study goes beyond this finding and adds a significant range of changes both in personal behaviour as in the organisation of society.

It shows how the combination of energy efficiency and changes in behaviour and societal organisation can lead to major reductions in energy demand. There is a large untapped potential in all demand sectors, especially in the buildings sector.

Figure 9 illustrates the significant energy reductions in all low carbon scenarios compared to the REFERENCE scenario. All three '-80% GHG' scenarios lead to major reductions. Even the more technology-focused scenario leads to almost 40% energy demand reductions compared to the reference case (-30% vs. 2010).

The EU integration scenario falls within the reductions range of the three '-80% GHG' scenarios. Although behaviour and societal organization levers are left at the same level as the reference scenario, this is compensated by a stronger focus on energy efficiency and electrification at level 4, which both support lower energy consumption. Once again this highlights that various pathways exist to reach similar outcomes, although leaving aside one dimension requires going very far into another.

The '-95% GHG' scenario highlights the level that can be reached by pushing all levers very far, up to ambition level 4. This leads to a maximum reduction, effectively halving the 2010 energy demand.

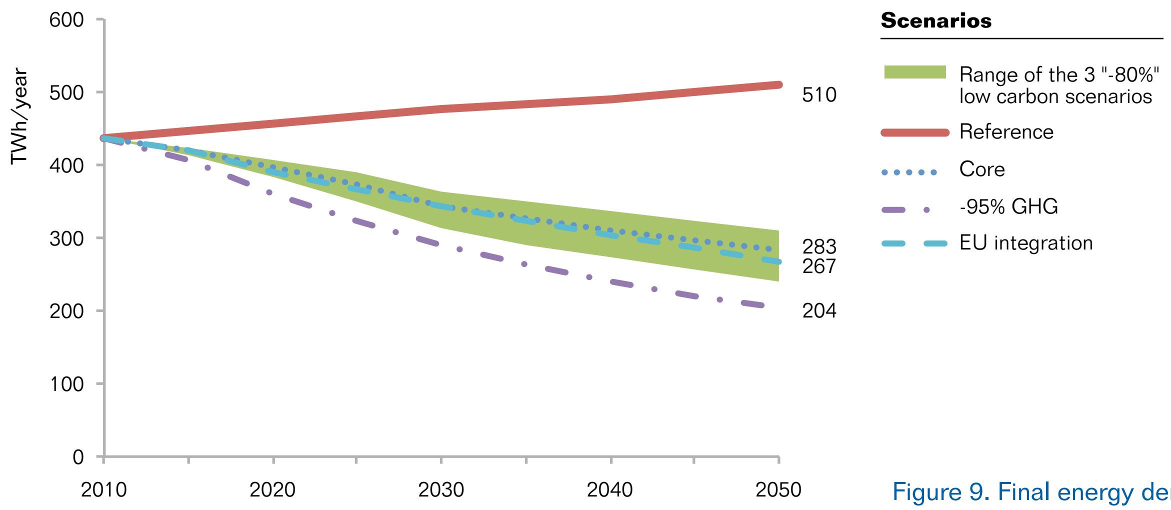


Figure 9. Final energy demand in the various scenarios.

Geothermal power station

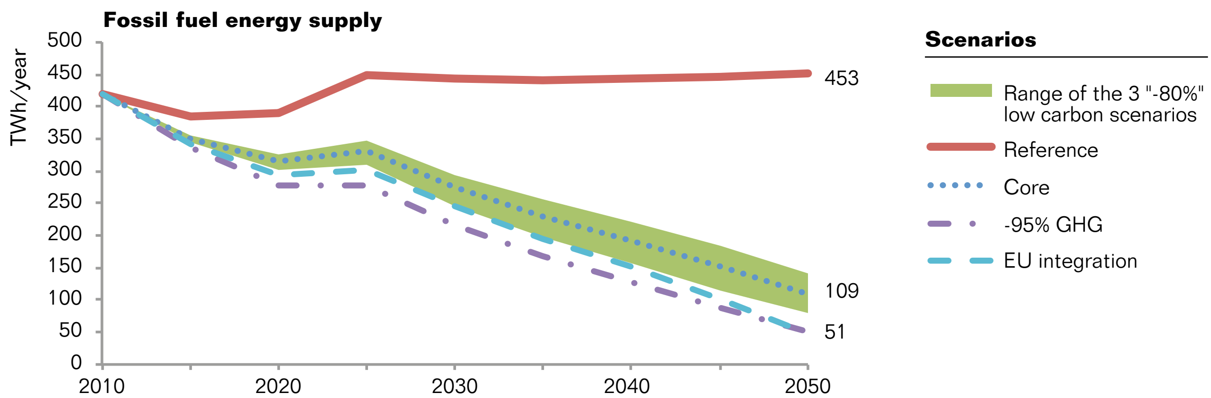
Fossil fuels are drastically reduced and renewables increase manifold.

FINDING 7

Along with substantial reductions in energy demand, energy supply needs to undergo a complete reconfiguration. The consumption of fossil fuel based energy would have to decrease to reach significant GHG emission reductions. Figure 10 shows how fossil fuel imports would consequently drop by 70-85%.

At the same time, energy production from renewable energy sources will need to increase, reaching by 2050 a level four times higher than in 2010. Still, the CORE scenario calls for only 12.5 TWh to be produced from photovoltaic panels by 2050 while their technical potential is estimated at over 40 TWh. Similarly, the production of wind energy reaches 19 TWh, compared to a potential of ~30 TWh. The deployment levels of non-intermittent renewables such as biomass (see finding 8) and deep geothermal energy is set to level 3, and is therefore closer to their respective technical potential.

It is worth noting the increase in fossil fuel use after 2020 when the remaining nuclear reactors are scheduled to be shut down. It is assumed that gas-fuelled power plants will replace this production in the short term, before being replaced over time by renewable energy sources or CCS.



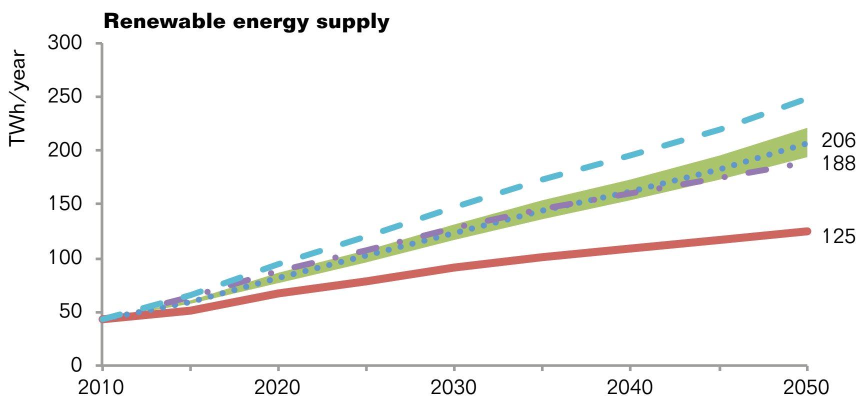


Figure 10. Fossil fuel and renewables based energy supply in the various scenarios.

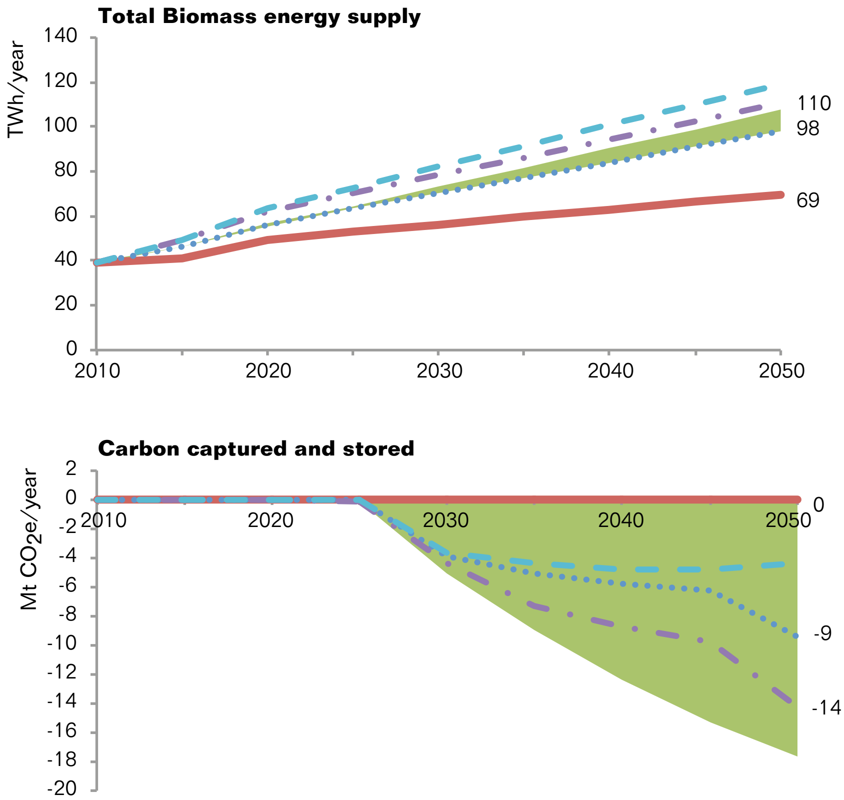
Sustainable biomass will likely be important for the low carbon transition. Carbon capture and storage could also play a significant role but raises concerns regarding its feasibility and potential risks.

FINDING 8

Biomass is a flexible, albeit limited, resource. There is likely to be further competition for biomass resources globally and from a number of other sectors such as food and paper. This study always considers biomass for energy as secondary to food and direct uses.

Utilisation of both domestically produced and imported bioenergy requires careful monitoring of many impacts, such as the impact of direct and indirect land use change, the effects on local livelihoods and natural ecosystems and the impacts on global food prices. Including sustainability criteria in the assessment of biomass potential for energy is therefore of crucial importance. Even using sustainability criteria, estimations of worldwide available bioenergy vary significantly. The level of maximum imports used in this work is based on the estimated maximum amount of sustainable biomass production worldwide. This potential is equally distributed per person worldwide. This leads to a potential of 80 to 120 TWh for Belgium in 2050 (including ~34 TWh of indigenous production). This potential is tapped significantly in almost all decarbonisation scenarios (Fig. 11 - upper graph).

Carbon capture and storage (CCS) could be applied both for power production and large industrial plants. At the moment, it is one of the only large scale solutions in development to reach substantial reductions for large industrial GHG emitters. However, it is currently experiencing delays in its anticipated development and concerns regarding potential leakage of the carbon stored have also been raised. The bottom graph shows that it would be technically feasible to reach 80% GHG reductions by 2050 without CCS (the BEHAVIOUR scenario has no deployment of CCS), but this would require increasing substantially the ambition level in other sectors. In the CORE scenario, 9 $MtCO_2e$ would be abated in 2050 based on CCS, effectively covering 8 large industrial sites.



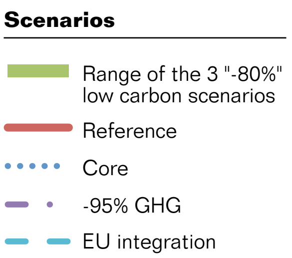


Figure 11. Bioenergy supply levels and CCS deployment in the various scenarios.

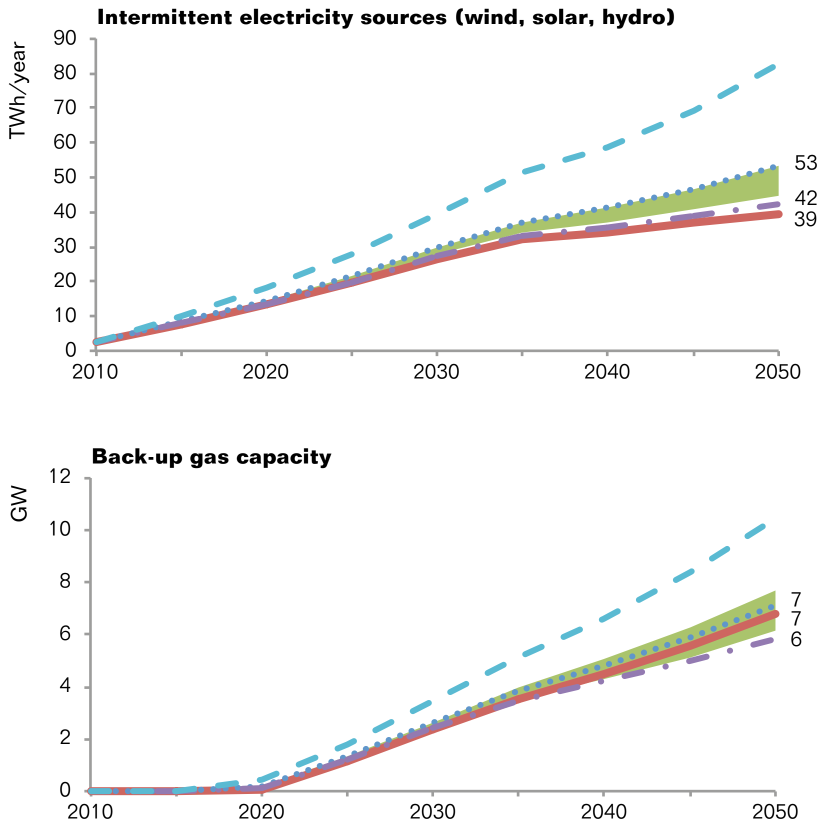
Intermittent energy sources will increase significantly. They are manageable but require large interconnection, back-up and demand-side management measures.

FINDING 9

The share of intermittent energy sources, such as solar and wind, will increase in all scenarios, even in the REFERENCE (see Figure 12 - upper graph). In most scenarios, the level of intermittency reaches 40 to 50%. In the EU INTEGRATION scenario however, the higher level of interconnection with neighbouring countries helps raise the level of intermittency to 60%.

Solutions exist to ensure that intermittent sources do not affect security of supply. Demand side management will play an important role in limiting the need for interconnection and back-up installations and could contribute to a reduction of 25 to 40% of additional transmission and back-up requirements. The development of a smart grid will harness a large amount of flexibility available at the consumers' level. The back-up capacity amounts to 7 GW in 2050 in the CORE scenario (see Figure 12 - lower graph), to be compared to the overall installed capacity of ~50 GW, of which about two thirds are intermittent (wind and solar). Interestingly, the REFERENCE scenario has similar back-up requirements because of its significantly higher power demand, even though it requires less back-up capacity per TWh.

Several European analyses highlight the strategic geographic situation of Belgium. From a European perspective, the optimal solution requires an increase in transmission capacity in Belgium to allow for electricity transfers between European states. Belgium would therefore become an electricity transmission hub within Europe. This option could be an opportunity for Belgium, by supporting employment through the construction, maintenance and exploitation of back-up plants and transmission lines. However, at the same time this solution could be a challenge in terms of use and protection of our natural habitat.



Scenarios

- Range of the 3 "-80%" low carbon scenarios
- Reference
- Core
- -95% GHG
- EU integration

Figure 12. Electricity from intermittent sources and back-up capacity in the various scenarios.

The low carbon transition requires additional investment expenditures that are compensated by reduced fuel expenses.

FINDING 10

The analysis focuses on the following energy system costs: capital expenditures (including infrastructure costs), fixed and variable operating costs and fuel costs. It shows that, in the three scenarios leading to 80% reductions and in the -95% GHG scenario, the costs in the low carbon scenarios are similar to those in the REFERENCE scenario (see Figure 13). Interestingly, total additional investment costs required for the low carbon transition are compensated by gains through the reduction in fuel expenses. In the EU INTEGRATION scenario however, costs are higher. This reflects the particularly low ambition levels assumed for some of the key demand drivers in this scenario, particularly for transport where there is no transport demand reduction and no shift to softer transport modes.

Differences can be found across sectors. In the transport sector, the shift from investments in individual transport (e.g. buying cars) to investments in collective transport (e.g. buying buses and trains) results in lower overall investment requirements in the low carbon scenarios than in the REFERENCE scenario. In the buildings sector, investments associated with the deployment of heat pumps account for the major part of the costs. In industry, total costs in the CORE scenario are no higher than those incurred in the REFERENCE scenario, at least not in the sectors where production is not affected by the low carbon transition. In the energy supply sector, with a supply mix based on more investments fixed costs increase drastically in the electricity sector, while fuel costs decrease massively.

The analysis does not prioritise scenarios on the basis of their respective costs: a comprehensive cost-benefit or cost-effectiveness analysis is beyond the scope of the study as it would require complementary analyses to assess many other impacts.

Its aim is to give an indication of the magnitude of the investments required and an idea of where these investments are needed, as well as to raise the critical issue of how to mobilise resources to finance these investments: the transition implies early investments financed by later fossil fuel economies and puts the question of financing at the heart of the debate.

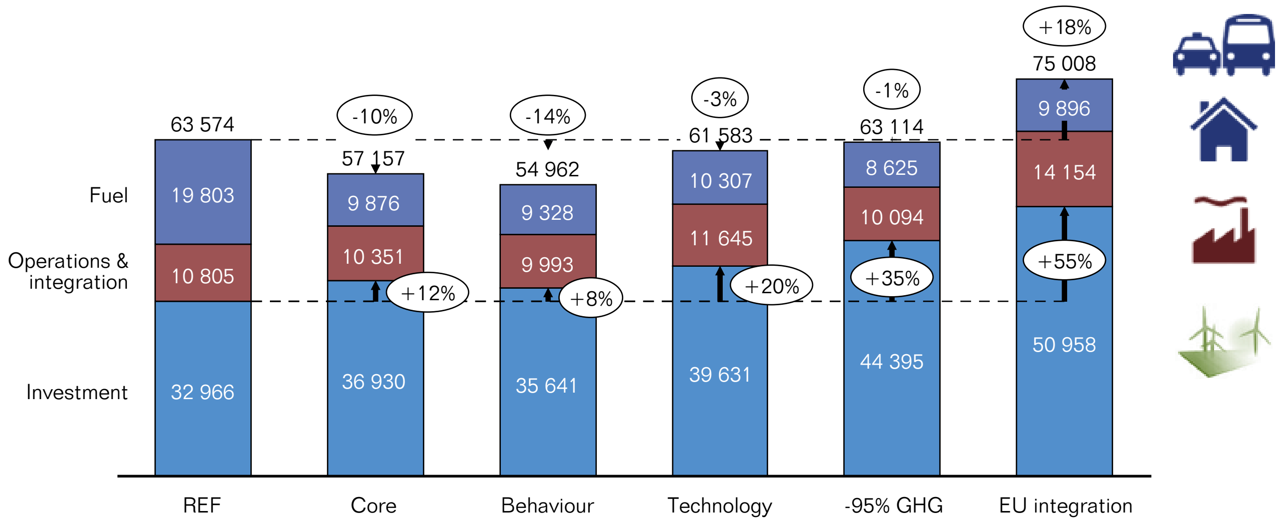


Figure 13. Average yearly system cost across scenarios (undiscounted 2010-2050, in million EUR).

F. Milestones to 2050

The OPEERA model is designed to understand implications in the long term up to the year 2050 and includes data, assumptions and results for intermediate milestones with a 5-year interval starting from 2010. Sectoral levers are implemented at the relevant time and pace. These milestones are not the result of any optimisation method. However, they give a good indication of near term challenges.

In the CORE scenario, the milestones in terms of GHG emission reductions with respect to 1990 are ~30% by 2020, ~45% by 2030 and ~60% by 2040 (see Figure 14).[8] Reductions occur at a relatively regular pace in all sectors with the exception of the energy sector in the years up to 2025 because of the gradual nuclear phase-out. Reaching 95% reductions domestically by 2050 requires deeper reductions earlier on, namely ~40% by 2020, ~60% by 2030 and ~80% by 2040.

8 These milestones are relatively similar to those computed by the European Commission at the EU level in its "Roadmap towards a competitive low carbon economy in 2050".

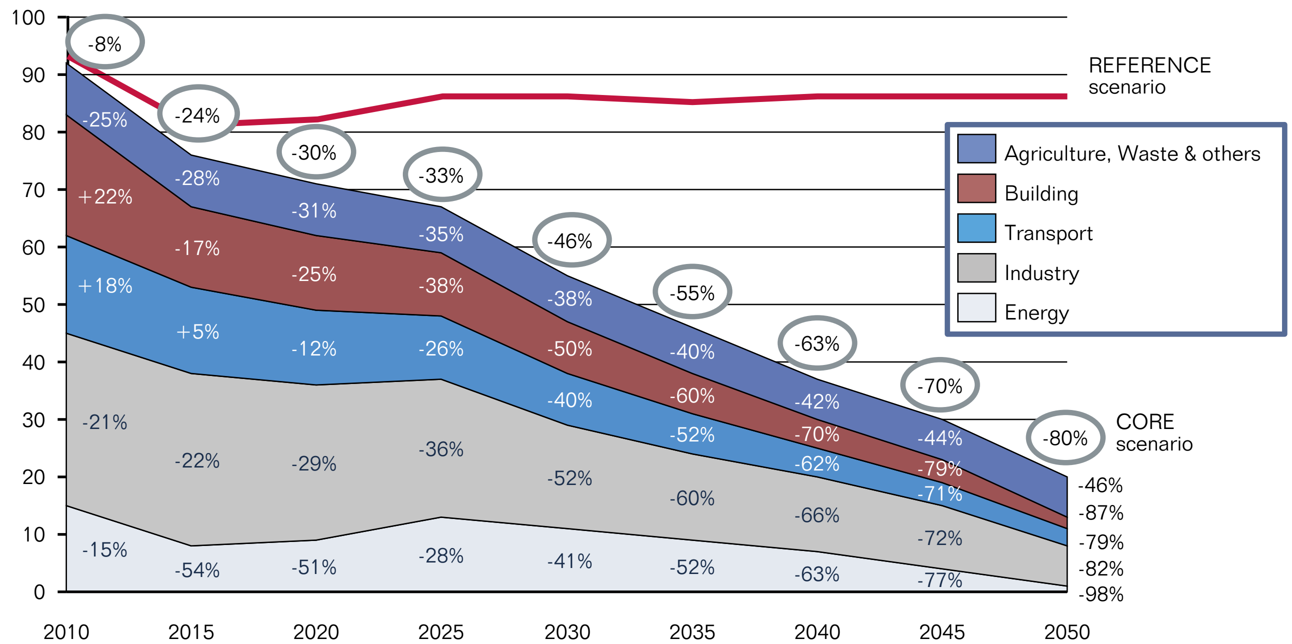


Figure 14. Evolution of GHG emissions per sector and in total w.r.t. 1990 (in %) in Belgium in the CORE scenario (index: 1990 = 100).

G. Conclusions

Attaining an 80 to 95 per cent GHG emissions reduction in Belgium is possible. Nevertheless, reaching this target is a heady challenge. It will imply large reductions in all sectors and a thorough understanding of the various interconnected dimensions is crucial.

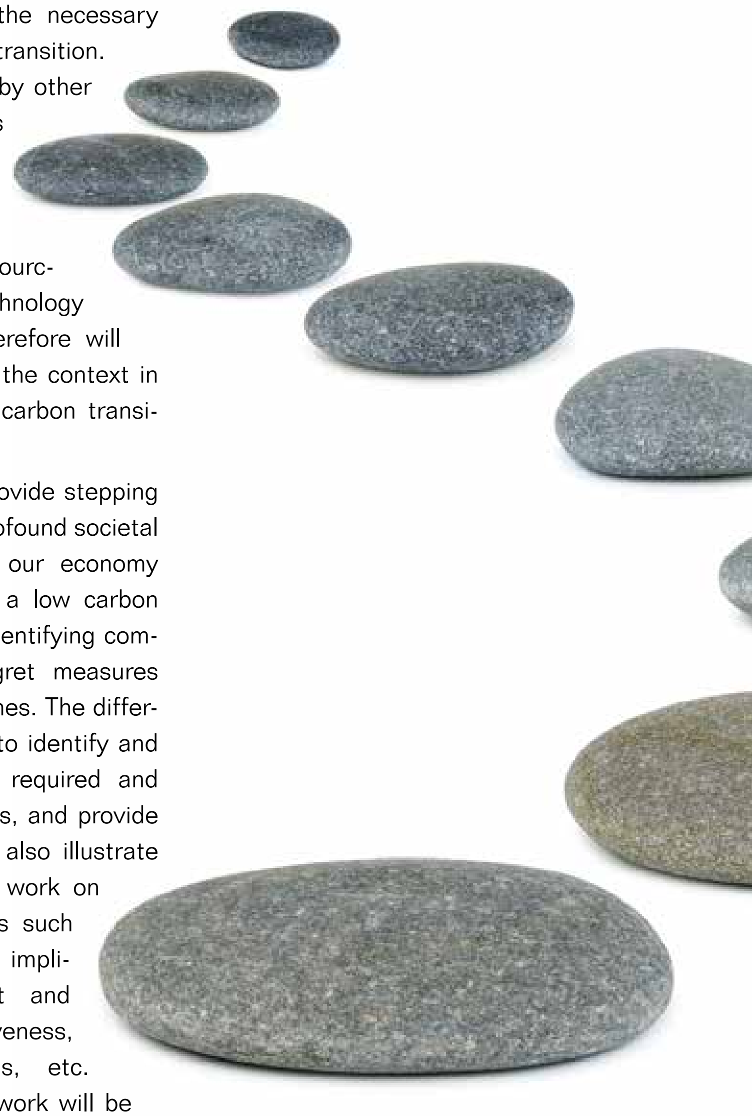
This study analyses various scenarios to achieve significant GHG emissions reduction objectives. The scenarios imply drastic changes from all actors in society. They request a clear political vision and a consistent framework allowing all stakeholders to engage in the low carbon transition while managing the many uncertainties of a 40-year time-horizon.

The study shows that, if managed correctly, the low carbon scenarios are situated in the same cost range as the reference scenario: large investments in energy efficiency, infrastructure, flexibility, renewable energy and interconnections are compensated by lower fuel expenses. It makes clear that energy savings in all sectors remain of central importance and that the transition can be made possible through early investments financed by later fossil fuel savings, placing the question of financing at the heart of the debate.

A low carbon transition offers opportunities and some ‘no regret measures’, such as renovating buildings, developing the energy infrastructure, or strengthening energy efficiency. However, critical barriers could make the transition difficult and thus moving to a low carbon society must come about in a coordinated way, in order to properly manage competitiveness issues, ensure security of supply and provide the necessary conditions for a just transition.

The directions taken by other regions and countries need to be taken into account as their decisions will affect the availability of resources, prices and technology development and therefore will have an influence on the context in which a Belgian low carbon transition will take place.

This study aims to provide stepping stones to initiate a profound societal debate on orienting our economy and society towards a low carbon development, while identifying common ground, no regret measures and essential milestones. The different scenarios intend to identify and outline the changes required and their main implications, and provide some answers. They also illustrate the need for further work on complementary topics such as macro-economic implications, employment and training, competitiveness, financing, co-benefits, etc. This complementary work will be important in identifying which pathway to 2050 is most desirable and deliverable.



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Colophon

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