TOWARDS A
LOW CARBON SOCIETY

Vision and strategic workstreams for a decarbonised Belgium by 2050

Input to the Belgian long-term strategy

FPS Health, DG Environment, Climate Change Section

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Executive summary

This document aims at identifying key orientations for the establishment of a long-term decarbonisation strategy for Belgium. It draws on a wide range of analyses, both quantitative and qualitative, of policy documents and scenario modelling for 2050. It develops a vision for the various GHG emitting sectors, including key indicative emission levels in 2050 and identifies policy levers for each of those sectors in order to decarbonize Belgium. With the view to advance work on the development of policies geared towards gradual decarbonization a series of strategic workstreams are proposed, sectoral as well as transversally.

GHG emissions in Belgium amounted to 114,5 $MtCO_2e$ in 2017, down by 22% since 1990. By 2050, in the context of a climate neutral European Union, Belgium could reduce its GHG emissions by about 95% with respect to 1990 and compensate the remaining gap by negative emissions, thereby reaching climate neutrality. The buildings, the transport and the power sectors could be fully decarbonised. In the industry and the agriculture and waste sectors, certain hard-to-abate emissions might not be completely phased out by 2050 and would need to be compensated by carbon absorption from natural sinks and, if needed, by carbon removal technologies such as BECCS or DAC with carbon sequestration. Table ES.1 illustrates indicative GHG emission levels in these sectors in Belgium, as a contribution to a climate neutral European Union by 2050.

Table ES.1: Overview of indicative 2050 GHG levels for Belgium in the context of a climate-neutral European Union ($MtCO_2e$ and %)

Sector	1990 GHGs (MtCO2e)	2017 GHGs (MtCO2e)	2050 orientation	2050 vs 1990 (2017)	2050 GHGs (MtCO2e)
Buildings	21,1	20,8	Complete decarbonisation	100% (100%)	0
Transport	25,1	25,9	Complete decarbonisation	100% (100%)	0
Industry	57,2	38,7	Almost complete decarbonisation with remaining emissions compensated by negative emissions	At least 90% (85%) **	Max 5,7 **
Power	22,9	13,1	Complete decarbonization	At least 100% (100%) **	Max 0 **
Agriculture	15,3	12,4	Complete decarbonisation of energy-related emissions and very large reduction of non-CO2 emissions	At least 70% (63%)	Max 4,6
Waste	5,0	3,6	Almost complete decarbonisation and very large reduction of non-CO2 emissions	At least 90% (86%)	Max 0,5
LULUCF and carbon removal technologies*	-3,3	-0,3	Remaining emissions compensated by natural sinks (LULUCF) and carbon removal technologies (e.g. BECCS in industry and power)	LULUCF: about 3% (4%) ***	LULUCF: -4 to -5
Total	143,3	114,3	Net zero GHGs	100%	0

* Carbon removal technologies such as BECCS (Bioenergy with carbon capture and sequestration) and DAC (Direct Air Capture) with sequestration.

** Without BECCS.

*** Ratio 'sinks and removals in 2050'/'Total GHG emissions in 1990 (2017)'

In order to reach such deep emission reductions, a large variety of levers needs to be activated in every sector. These levers mainly relate to technological developments and to lifestyle and organizational changes which need to be enabled and incentivised by a large set of policies and measures at all government levels. Such levers are systematically analysed in this document.

It is also important to align policy frameworks in the various policy areas covered and to gather further strategic and technical insights into specific issues so as to provide all relevant actors with a robust basis for policy decisions and strategic choices. To that end, the present document proposes and develops a number of transversal and sector-specific workstreams which are listed in Table ES.2 below.

Table E.S 2: Overview of transversal and sector-specific strategic workstreams

STRATEGIC WORKSTREAMS	
Buildings	
B1	Alignment of economic instruments with the long term objectives
B2	Energy poverty and housing
B3	Alignment of labour market policies and support of business models for renovation
B4	Framework for a circular economy in construction and renovation
B5	Investment plans and financing strategy for publicly owned buildings
Transport	
T1	Long-term vision on mobility
T2	Investment plans and financing strategy for public and active transport modes
T3	Alignment of economic instruments with the long term objectives
T4	Framework for the development of new transport models
T5	Promoting freight transport technological developments
Industry	
I1	Industrial roadmaps for competitive, innovative and climate-friendly industries
I2	Mapping and scaling-up of circular economy strategies and plans
I3	Electrification: challenges and opportunities for electro-intensive industries
I4	Vision and framework for the use of biomass, hydrogen, e-fuels and carbon capture
I5	National industrial strategy for a bio-economy
Energy production	
P1	Long-term vision on electricity supply
P2	Green hydrogen and e-fuels production and infrastructure
P3	Long-term framework for the integration of intermittent sources by all actors
P4	Support to the active role of citizens
LULUCF	
A1	Vision for a sustainable agriculture
A2	Role of the carbon sinks in reaching negative emissions in Belgium
A3	Strategy for a bio-economy : supply side
A4	Land use and biodiversity
Transversal	
O1	Governance framework
O2	Green finance strategy
O3	Just transition
O4	Negative emissions
O5	In-depth risks and vulnerability assessment of the consequences of climate change in Belgium

1. Introduction

At international level, in order to formulate a solution to the climate urgency, 195 Parties to the UN Framework Convention on Climate Change (UNFCCC) agreed in Paris in December 2015 to jointly take actions to combat climate change under the so-called *Paris Agreement*. Under this agreement, Parties committed to holding the increase in the global average temperature to well below 2°C above pre-industrial levels and to pursuing efforts to limit the temperature increase to 1.5°C. In order to be able to reach this objective, global greenhouse gas emissions need to decrease as soon as possible, and a balance between anthropogenic emissions and removals (i.e. carbon neutrality) must be achieved by the second half of this century. Furthermore, Parties committed to developing a long-term low GHG emissions development strategy by 2020. At EU level, this commitment also became a legal requirement under the so-called Governance Regulation, so that each member state is to submit a long-term strategy by the 1st of January 2020[1]. Under the Paris Agreement, it is encouraging to see that not only Parties are developing and submitting long-term strategies, but also many private and local actors have decided to commit to long-term objectives and present strategies to comply with these commitments.

At EU level, the 2011 EU Roadmap towards a competitive low-carbon economy in 2050 already set the direction for the EU to reach the set objective of reducing GHG emissions by 80% to 95% by 2050 compared to 1990. On this basis and following discussions and guidance from the European Council, the EU Commission made proposals for a 2021-2030 policy framework on climate and energy in 2014 that led to the 2030 strategy with targets on reducing GHG emissions by at least 40%, increasing the share of renewable energy to at least 27%, and achieving energy efficiency improvements of at least 27%. Legislation then revised these last two targets upwards to at least 32.5% for energy efficiency and at least 32% for renewables and the Governance regulation also introduced instruments to ensure coherent long term energy and climate policy planning. Under the Energy Union, in order to implement the 2030 targets, a revised ETS directive was also adopted that increases the annual ETS cap reduction in order to achieve 43% emission reductions by 2030 compared to 2005, while the Market Stability Reserve was strengthened to address the surplus of EU allowances. Furthermore, the 2030 Effort Sharing Regulation (ESR) together with the Regulation on the inclusion of GHG emissions and removals from LULUCF, regulate emissions and removals of the non-ETS sectors. It does so by setting emission trajectories and reduction objectives per member state[2].

Taking all of these elements into account, as well as the recent 1,5°C IPCC report, the European Commission presented the "A Clean Planet for all: A European long-term strategic vision for a prosperous, modern, competitive and climate neutral economy" communication, wherein eight pathways that build on no regret policies (e.g. strong use of renewable energy and ambitious energy efficiency improvements) were assessed that lead to respecting the commitments taken on under the Paris Agreement. Some of these pathways assess how Europe is to transition towards net-zero emissions and thus to carbon neutrality by 2050.

1 According to Art. 15 of EU Regulation (EU) 2018/1999 of 11 December 2018, whereby Annex IV is to be used as template for the strategy document to be submitted.

2 For Belgium, a GHG emission reduction objective of 35% by 2030 (compared to 2005) was set under the ESR.

In this context, the present document intends to contribute to the development of a long-term strategy in Belgium. It develops a vision for the various GHG emitting sectors, including indicative emission levels in 2050 and identifies policy levers for each of those sectors in order to decarbonize Belgium. It draws on a wide range of analyses, both quantitative and qualitative, of policy documents[3] and scenario modelling for 2050. Ongoing modelling work[4] will complement the quantitative insights with, i.a., indicative GHG emission reduction milestones on the trajectory to 2050, as well as insights regarding possible energy demand levels and the contribution of different energy sources, also at sectoral level. It will also provide more detailed insights, such as the extent of the modal shift in the transport sector, the degree of renovation of buildings, etc., in various transition scenarios.

A series of strategic workstreams are identified. Although several workstreams are closely intertwined, each of them constitutes a domain, an axis for which orientations must be drawn, decided on and, step by step, implemented. They must be launched quickly to help guide investment and behavioural choices in the direction of decarbonization and to avoid carbon lock-in. The development of these workstreams necessarily involves the active and joint participation of the actors and stakeholders concerned, the public authorities concerned by the underlying policies, as well as the mobilization of the expertise required, including at the academic level. It should start from existing analyses performed by a variety of actors and on existing, even partial, orientations, visions and strategies available at different governmental levels.

The document is structured as follows. The second section presents an overview on where we currently stand regarding GHG emissions and in terms of the possible indicative pathways towards climate neutrality in Belgium in 2050. The third section provides a deep-dive per sector (buildings, transport, industry, energy production, agriculture, forestry and land use, and waste), according to the following structure: (i) where we are, (ii) vision, (iii) levers and pathways, and (iv) workstreams. The fourth section highlights other important transversal issues or enabling conditions for a transition towards climate neutrality, including workstreams related to these transversal issues.

3 See in particular the Low Carbon Belgium 2050 analyses (see climatechange.be/2050), including “Scenarios for a low carbon Belgium by 2050” (2013) and the current update of these scenarios (forthcoming), the study on the “Macroeconomic impacts of low carbon scenarios in Belgium” (2016), the Energy Pact (December 2017), the Strategic Investment Pact (2018), the National Climate and Energy Plan and in particular its Federal Component (Dec. 2019), the Communication from the European Commission: "A Clean Planet For All" (2019), the study "A net-zero greenhouse gas emissions - Belgium 2050 - Initiating the debate on transition policies" (2019).

4 Scenario analyses have been performed with the Belgian 2050 pathways calculator. This new calculator updates the OPEERA calculator developed in 2013 (see www.climatechange.be/2050) and builds on recently developed the EU Horizon 2020 funded EU pathways calculator (see www.european-calculator.eu).

2. Overall aspects

2.1 Where we are

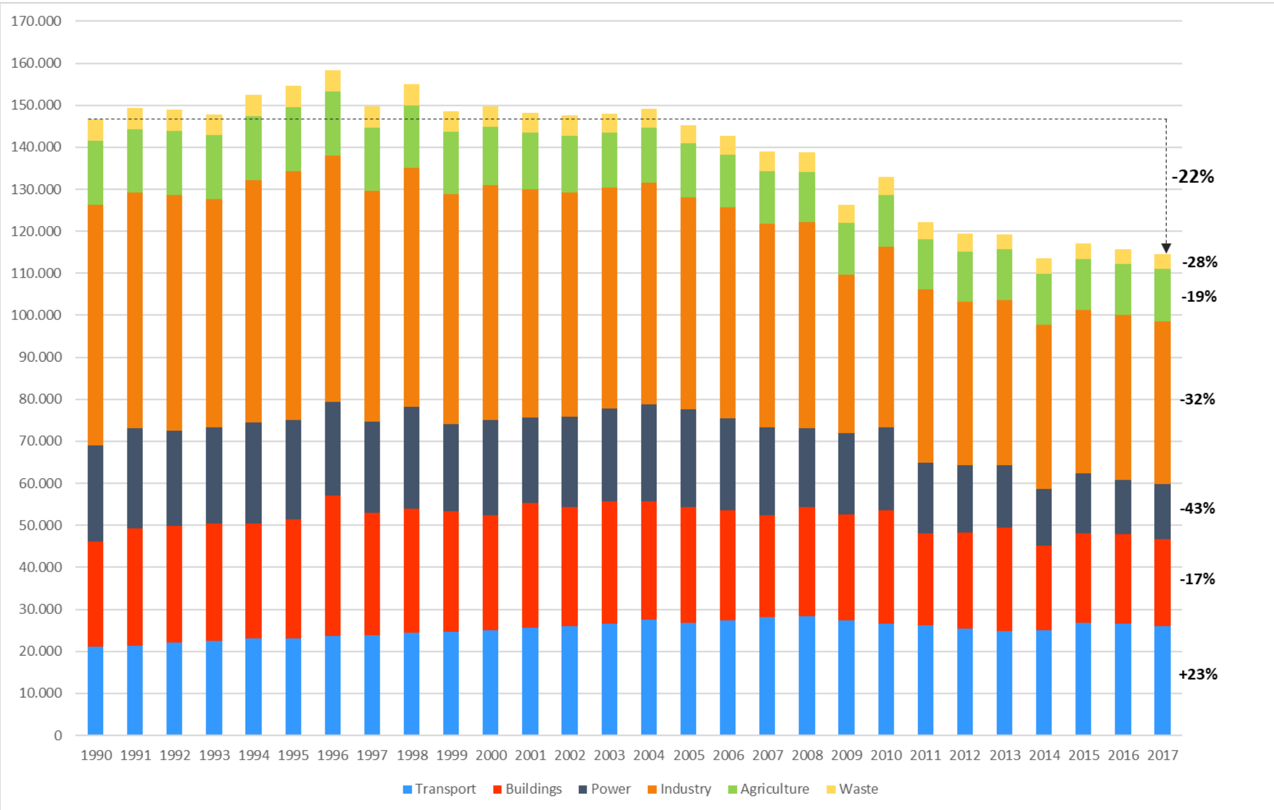
Total GHG emissions in Belgium amounted to 114,5 MtCO2e in 2017, down by 22% with respect to 1990 and 21% with respect to 2005 (see Figure 1).

The largest GHG emitting sectors in Belgium are the industry sector (combustion and processes together – around 33,5% of total Belgian GHG emissions in 2017), the transport sector (23%), the buildings sector (18%) and the power sector (11,5%), followed by the agriculture sector (11%) and the waste sector (3%). In 2017, GHG emissions covered by the EU ETS reached 38% of total emissions in Belgium, while the sectors not covered by this scheme represented 62% of total GHG emissions (see Figure A1 in appendix for a view of on the split between emissions covered by the EU ETS and emissions falling outside this scheme).

In terms of sectoral evolutions, the strongest emission reductions occurred mainly in the energy and industrial sectors (-43% and -32% compared to 1990, respectively) while emissions have significantly increased in the transport sector over the period (+23%).

Figure 1 : Evolution of BE GHG emissions

(excl. LULUCF - in ktCO_2e and percentage change w.r.t. 1990)



Source: NIR 2019

2.2 Indicative pathways towards climate neutrality[5]

By 2050, in the context of a climate neutral European Union, Belgium could reduce its GHG emissions by about 95% with respect to 1990 and compensate the remaining gap by negative emissions, thereby reaching climate neutrality.

The way such deep emission reductions can be achieved in each sector is analysed in depth in the next section. In a nutshell, the buildings, the transport and the power sectors could be fully decarbonised. In the industry and the agriculture and waste sectors, certain hard-to-abate emissions might not be completely phased out by 2050 and would need to be compensated by carbon absorption from natural sinks and, if needed, by additional carbon removal technologies such as BECCS in industry and in power or DAC with carbon sequestration. Table 1 below illustrates indicative GHG emission levels in these sectors in Belgium, as a contribution to a climate neutral European Union by 2050, both in terms of absolute emissions and as a difference with respect to 1990 and 2017 emissions.

Table 1: Overview of indicative 2050 GHG levels for Belgium in the context of a climate-neutral European Union (MtCO2e and %) [similar to Table ES.1]

Sector	1990 GHGs (MtCO2e)	2017 GHGs (MtCO2e)	2050 orientation	2050 vs 1990 (2017)	2050 GHGs (MtCO2e)
Buildings	21,1	20,8	Complete decarbonisation	100% (100%)	0
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Industry	57,2	38,7	Almost complete decarbonisation with remaining emissions compensated by negative emissions	At least 90% (85%) **	Max 5,7 **
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Total	143,3	114,3	Net zero GHGs	100%	0

* Carbon removal technologies such as BECCS (Bioenergy with carbon capture and sequestration) and DAC (Direct Air Capture) with sequestration.

** Without BECCS.

*** Ratio 'sinks and removals in 2050'/'Total GHG emissions in 1990 (2017)'

5 This section corresponds to sections 2.1 to 2.3 (except section 2.1.3 which is dealt with in section 4 of the present document) of appendix IV of the EU governance of the energy union regulation.

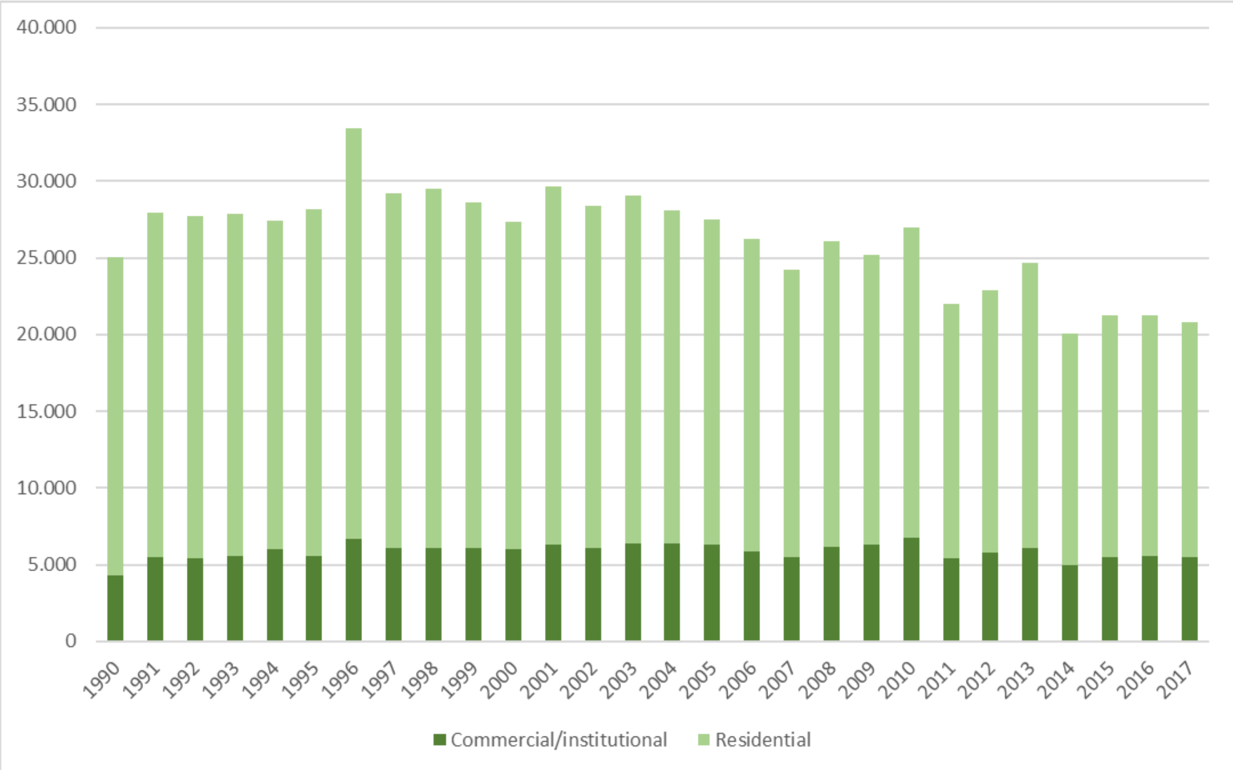
3. Sectoral aspects

3.1 Buildings

3.1.1 Where we are

The buildings sector accounted for 18,3% of total GHG emissions in 2017. Total emissions in the buildings sector have had a downward trend between 1990 and 2017 (see figure 2). Total emissions in 2017 were 17% lower than in 1990, and 24% lower than in 2005. Main driver is the residential sector, even though a downward trend is also noticeable in the commercial/institutional sector from 2005 onwards. In 2017, 73% of total buildings emissions originated from the residential sector, while 27% stemmed from the commercial/institutional sector.

Figure 2 : GHG emissions in the buildings sector, 1990-2017
(in $ktCO_2e$)



Source: NIR 2019

Emissions in the building sector originate mainly from natural gas and oil (see figure A1 in appendix). In the residential buildings sector, GHG emissions from combustion of liquid fuels reached 39%, of gaseous fuels 44%, biomass 16% and other fuels 1% in 2017. In the non-residential, liquid fuels represented 18% of sector emissions in 2017, gaseous fuels 75%, biomass 4% and other fuels 3%.

As to the evolution of GHG emissions in the residential sector, fuel consumption increased by 15% between 1990 and 2003, mainly due to the growing amount of houses (+26% between 1990 and 2001). Energy consumption and therefore GHG emissions likely gradually decreased throughout the period due to increasing energy prices and improved energy efficiency. Emissions in this sector are of course also significantly dependent on the climatic circumstances in a specific year: in years with exceptionally cold (e.g. 1996, 2010, 2013) or warm winters (e.g. 2007, 2011, 2014), emissions from heating are considerably higher and lower, respectively.

In the commercial sector, fuel consumption increased by 46% since 1990. Although climatic circumstances are also a factor here, it is less so than in the residential sector. The increase is mainly due to an increased amount of employees (+29% between 1990 and 2014), but also due to a 94% increase of electricity consumption over the same period that is mainly due to increased use of information technologies and of cool spaces and air conditioning.

When we look at projected levels of emissions with current policies by 2030 in the context of the National Energy and Climate Plan, emissions are set to reach a reduction of 19% compared to 1990. With the additional policies and measures adopted in the Plan, emissions in the buildings sector would decrease by 36% compared to 1990.

3.1.2 Vision

By 2050, greenhouse gas emissions in the buildings sector could be reduced by 100% thanks to a drastic reduction of its energy consumption in combination with a carbon-free energy mix.

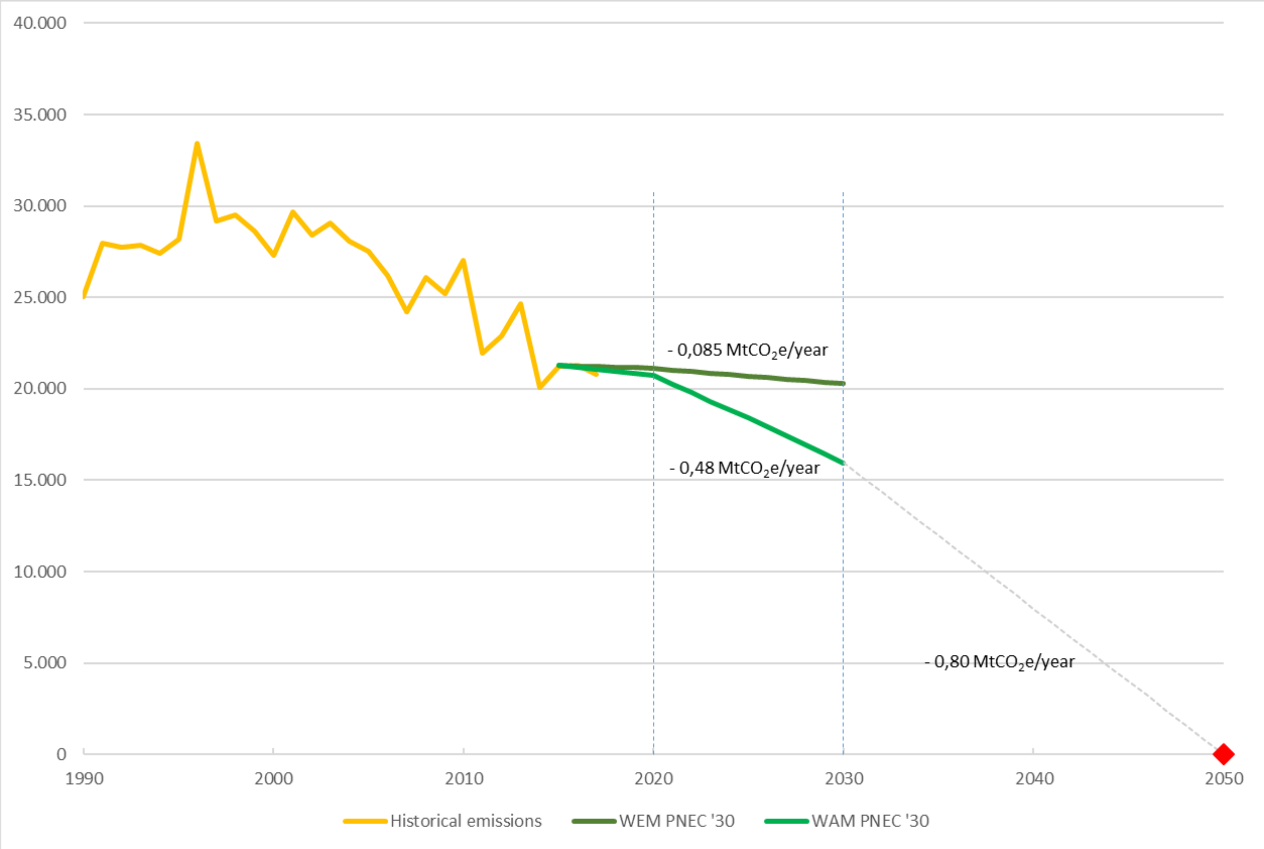
The required energy performance level of the building stock has been achieved through **deep retrofits** of the existing building stock and carbon neutral new buildings, whereby circular economy principles and a rational use of material are applied, as well as through **lifestyle changes**. The remaining energy demand is met with **renewable sources**, including heat pumps, geothermal energy, sun boilers, sustainable heating networks and where appropriate and necessary, with biomass, biogas or possibly hydrogen and e-fuels produced with sustainable electricity.

In this context, urban and **spatial planning** has been redesigned in such a way that the best and most efficient choices have been made for each building (area) in function of its location and the related availability of energy sources. A focus on urban densification will enhance efficient and sustainable use of energy and result in co-benefits in other sectors (enhanced sustainability in the transport sector, in the services and utilities sector, in agriculture, etc.).

Overall, the existing building stock will reach a comparable energy performance level by 2050 as new built dwellings with building permit from 2015 [ref: Energy Pact]. The **residential** building stock has to reach an average energy performance factor of max. 100 kWh/m². [ref. Energy Pact] by 2050; as for social housing, this objective already has to be reached by 2040 [ref. Energy Pact]. **Non-residential** buildings have to be energy-neutral by 2050 at the level of heating, hot water, cooling and lighting [ref. Energy Pact]. Public buildings have to be energy-neutral by 2040 [ref. Energy Pact]. Together with electric vehicles, energy storage in residential buildings and by SMEs is to reach a total capacity of around 1,5 GW by 2030 (and already reach around 40% of this level by 2025). [ref. Energy Pact].

Figure 3 illustrates the historical emissions and the projected emissions up to 2030 with existing measures (WEM) and with additional measures (WAM) as foreseen in the National Energy and Climate Plan (NECP). The 2050 emissions level corresponding with full decarbonisation is also depicted. It shows that, if the measures foreseen in the NECP effectively deliver the expected emission reductions by 2030, the average annual emission reduction effort in the period 2030-2050 will have to increase by about 68% with respect to its level in the period 2020-2030 under the current 2030 ambition level.

Figure 3 : Historical emissions and projections in the buildings sector in relation to the 2050 emissions level corresponding with full decarbonisation
(in $ktCO_2e$)



Sources: NIR 2019, NCEP, own calculations, BE 2050 Net-zero study

3.1.3 Levers

Energy savings

A first set of levers is the level of **living area demand** (in m²/capita) of households and the related share of households living in apartments. Households can gradually require less living area and live in more compact dwellings, which would reduce energy demand.

Another group of levers relates to the average **temperature demand** inside buildings. A modified average temperature demand, including through better temperature management that still ensures a proper level of comfort, can lead to energy savings related to space heating and cooling. **Smart technologies** in buildings (e.g. automation and control systems) can significantly reduce energy consumption related to space heating and cooling, facilitate the use of renewable energy sources, and improve demand-side management while guaranteeing comfort and environmental quality.

The energy performance of buildings can be drastically improved. In this context, the **renovation rate and depth** of existing dwellings (roof, walls, windows, floors, …) has to be significantly increased. **Demolition** and rebuilding can take place where renovating is inefficient. For **newly built buildings**, stringent norms and standards can be applied immediately.

Finally, a more rational utilization and substitution rate of black and white **appliances** by households results in energy savings in the buildings sector (as well as related emissions reductions in industry due to reduced production volumes).

Buildings energy supply

The use of **renewable energy** sources and technologies, including electrification, can be generalized for meeting the remaining energy demand. Priority can be given to heat pumps where possible and to district heating. H2 and e-fuels based on renewable electricity can be used as a complement in buildings that cannot reach a sufficiently high degree of renovation.

Smart buildings can also **provide flexibility to the grid** by dynamically managing demand and optimizing the use of local on-site energy production (e.g. electricity from PV panels) and relying, when available, on on-site **storage** capacities (both stationary and embedded in appliances and vehicles).

Spatial planning

In the context of spatial development, building forms, sun orientations and materials can be chosen so that lead to lower energy consumption.

Spatial energy strategy can be developed at local level (including collective systems like district heating) and additional average daily usage of space can be progressively reduced to zero. Strategic collective transport junctions are further developed, and the housing density as well as surface allocated to companies at walking distance from these junctions are substantially increased.

3.1.4 Strategic workstreams

B.1) Alignment of economic instruments with the long term objectives

A fiscal reform should be adopted to align behaviours and investment decisions with the decarbonization challenges in the buildings sector. It should include the implementation of a gradually increasing and long-term oriented carbon price/carbon dividend signal in the buildings sector whereby the collected revenues are used to finance the transition in the sector with special attention for energy-poor households. It should also possibly include specific changes in current fiscal policies (such as for instance alignment of indirect taxation for renovation, demolition and rebuilding and new built). New instruments for buildings renovation are also required to facilitate the financing of the required investments in renovations. Finally, specific instruments need to be developed to overcome the "split incentive" issue between tenants and landlords.

B.2) Energy poverty and housing

Decarbonisation of the buildings sector requires major investments in retrofitting and in heating systems, while 21.7% of Belgian households were affected in 2017 by one or another form of energy poverty[6]. A national strategy aimed at supporting the transition for energy-poor households should be developed. It should be based on levers available at federal and regional levels, some of which would need to be reinforced and/or reformed. Social housing policies, including investment for deep renovation, need to be an essential part of such a strategy.

[6] Cf. Fondation Roi Baudoin, Baromètre de la pauvreté énergétique, 2019.

B.3) Alignment of labour market policies and support of business models for renovation

The transition to zero emissions in the buildings sector requires qualitative, accessible (both for households and companies) and drastically higher rates of renovations. These requirements should be integrated into labour market policies, in terms of workforce availability and of skills. Indeed, the task profiles of construction workers will change considerably due to the transition. The challenge of changing job profiles will be to align education and training in order to meet the emerging skills needs.

Technological and organizational solutions are needed to substantially enhance and speed up the renovation process. New business models that provide integrated home renovation services can play an important role in this regard. These should be based on an intensive cooperation between consumer organisations and business (producers of building materials and equipment, energy companies and installers), as well as on far-reaching digitalization (all information on building type, construction date and type, materials, etc. but also on interventions, suppliers, etc. are digitally available on one single platform, from the construction to the demolition of a building). Essential elements of these new business models are profound industrialization and innovation in the supply chain (industrial integration instead of several different processes) and bundling in the demand side, so that faster and more standardized solutions that can be scaled-up and thus applied more easily are developed. These solutions will lead to the necessary volume increase and thereby to product and process efficiency as well as reduced system costs.

B.4) Framework for a circular economy in construction and renovation

Retrofitting and construction involve the use of a large amount of materials such as cement, steel, plastics or wood. In order to reduce the carbon footprint and other environmental footprints of these materials (through their extraction, production (see chapter on industry) and transport for instance), it is of outmost importance to fully integrate the buildings decarbonization challenge, and in particular the renovation strategies, into the circular economy strategies and plans, and vice-versa. The choice of materials used for renovating buildings and the choice between renovation vs demolition and rebuild are two examples where such interactions are essential.

B.5) Investment plans and financing strategy for publicly owned buildings

The goal is to achieve energy-neutral public buildings by 2040. The "Strategic Investment Pact" quantifies the amount to be invested in public buildings at about 150 M€ per year up to 2030. This evaluation should be refined in order to draft a financing strategy and investment plan for publicly owned buildings. A database including all details (building type, construction date and type, materials used, energetic characteristics, etc.) should be set up by the beginning of 2021. The next step should be to develop and implement a financing strategy for large-scale public buildings' renovation in the course of 2021. Given the diversity of public buildings, the best financing option in function of the type of buildings and related action plans needs to be determined (e.g. public-private partnerships, green bonds, etc.). Finally, based on this financing strategy and on the identified best options per type of building, specific investment plans should be determined for each major actor involved in the renovation of public buildings, whereby their link with yearly and/or multi-yearly budgets should be clarified.

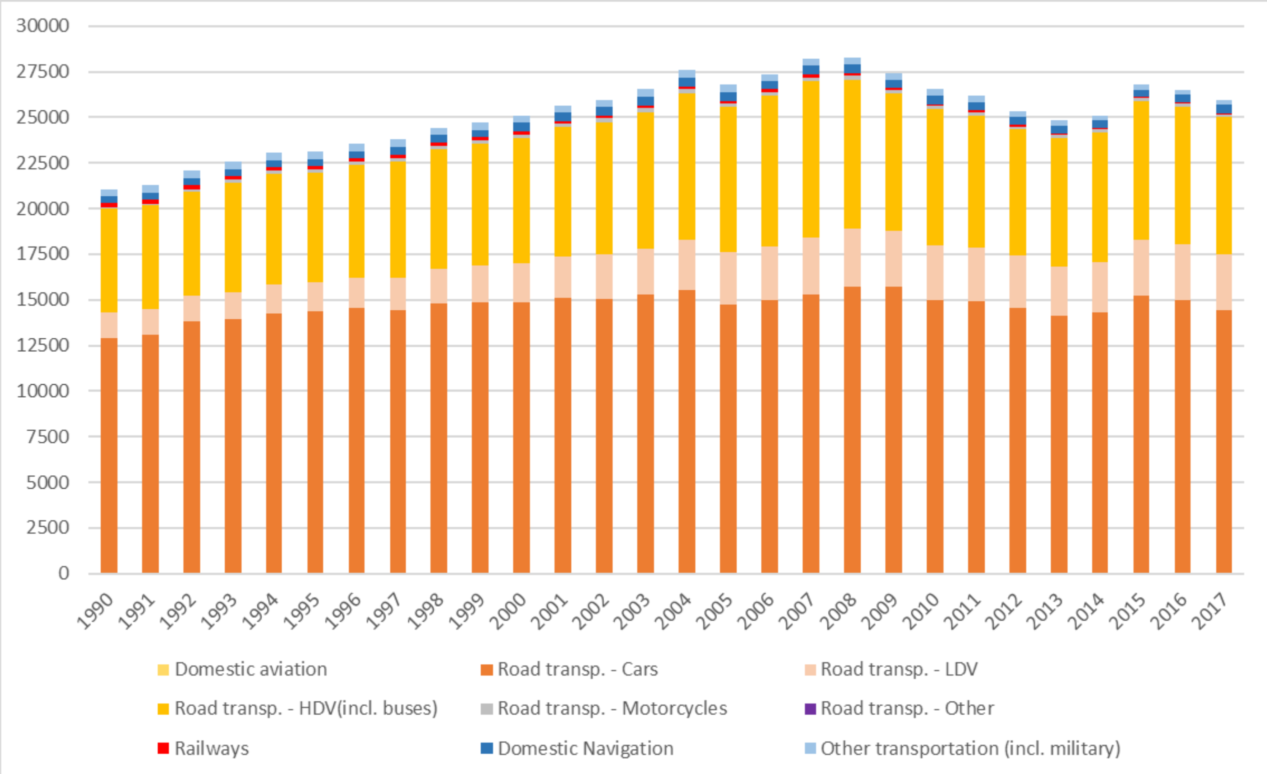
3.2 Transport

3.2.1 Where we are

The transport sector accounted for 23% of total GHG emissions in 2017. Total emissions in the transport sector have experienced an upward evolution between 1990 and 2008, after which they decreased in the period 2009-2013. The transport emissions increased again between 2014 and 2015, after which they decreased again in 2016 and 2017. This can be seen in Figure 4 below.

Figure 4 : GHG emissions in the transport sector, 1990-2017

(in ktCO2e)



Source: NIR 2019

In 2017, the largest share of emissions in this sector was generated by road transport by cars (56%), followed by road transport by Heavy Duty Vehicles (HDVs – 29%, including buses) and road transport by Light Duty Vehicles (LDVs – 12%). The remaining emissions in this sector stem from domestic navigation (1,71%), other (0,97%), motorcycles (0,59%), railways (0,26%) and domestic aviation (0,05%).

In terms of fuels used, 66% of 2017 CO2 emissions from cars stem from combustion of diesel, 27% of gasoline, 5% of biomass and 1% of LPG (see Figure A2 in the appendix). Regarding light-duty trucks, 92% of 2017 CO2 emissions come from combustion of diesel, 5% of biomass and 3% of gasoline. Finally, regarding heavy-duty trucks and buses, 94% of 2017 CO2 emissions stem from the combustion of diesel and 6% of biomass.

As to the evolution of GHG emissions in the transport sector in the period 1990-2017, almost all indicators in the road transport sector show an increasing trend in 2017: the number of vehicles increased by 59% compared to 1990, and also the number of vehicle kilometres increased by 47% in the same period. Freight transport increased by 114% and passenger transport by 26% over the same period.

When we look at projected levels of emissions with current policies by 2030 in the context of the National Energy and Climate Plan, emissions are set to reach an increase of 35% compared to 1990. With the additional policies and measures adopted in the Plan, emissions in the transport sector would reach a 7% decrease compared to 1990.

3.2.2 Vision

By 2050, greenhouse gas emissions in the transport sector (excluding emissions from bunker fuels) could be reduced by 100%.

[Demand] Total passenger transport demand and total freight transport demand in Belgium in 2050 are not higher than their respective current levels [Energy Pact][7], meaning that total transport demand per capita significantly reduces over the same period.

[Modal shift] Public transportation and active transport modes, including cycling, represent a large share of passengers transport. As for freight, a large share of goods is transported by rail and by inland waterways and delivery in city centers is facilitated.

[Technology switch] Remaining energy needs of the transport sector are met through decarbonized energy carriers, such as electricity, which will play a major role in decarbonizing passenger vehicles, as well as hydrogen, e-fuels and biofuels, which will be mainly deployed in transport modes that are harder to decarbonize, such as trucks and international transport. For public authorities and for public transport, all newly bought cars and buses will be zero emissions from 2025 on [Ref. Energy Pact[8]]. In 2030, the country will be equipped with sufficient public charging points to supply the entire country; Belgium strives for 1 public charging point per 10 electric vehicles, along regional roads and motorways we clearly opt for fast charging points [Ref. Energy Pact]. So-called 'empty-kilometers' by autonomous vehicles are minimized.

Figure 5 illustrates the historical emissions and the projected emissions up to 2030 with existing measures (WEM) and with additional measures (WAM) as foreseen in the National Energy and Climate Plan (NECP). The 2050 emissions level corresponding with full decarbonisation is also depicted. It shows that, if the measures foreseen in the NECP effectively deliver the expected emission reductions by 2030, the average annual emission reduction effort in the period 2030-2050 will have to increase by about 67% with respect to its level in the period 2020-2030 under the current 2030 ambition level.

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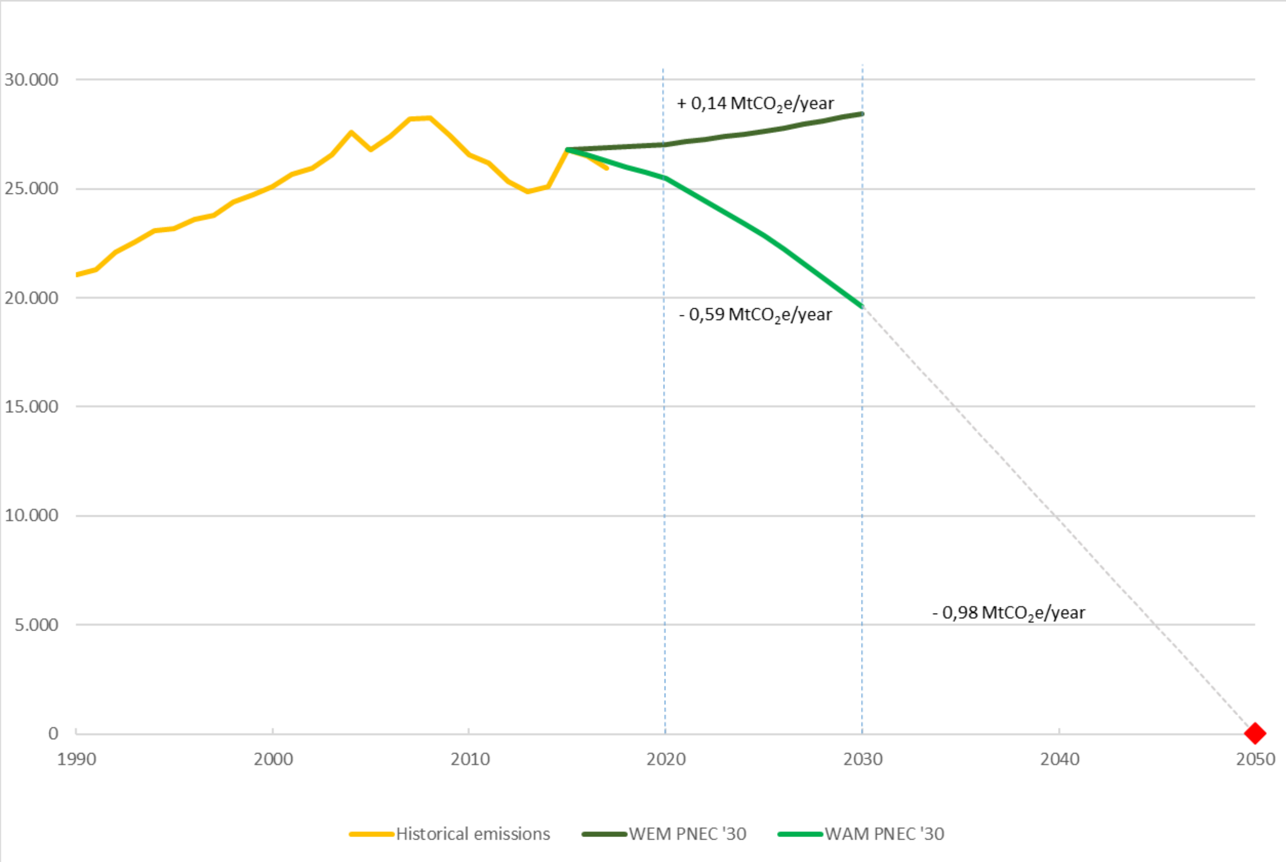
[7] Energy pact: "Total transport demand in 2050 will be equal to the level in 2017, despite an increasing population."

[8] Energy Pact: "Voor overheden en publiek transport (buslijnen) worden alle nieuw aangekochte wagens en bussen zero emissie tegen 2025."

Figure 5 : Historical emissions and projections in the transport sector, in relation to the 2050 emissions level corresponding with full decarbonisation

(in $ktCO_2e$)



Sources: NIR 2019, NCEP, own calculations, BE 2050 net zero study

3.2.3 Levers

Demand

Total distances driven by vehicles can be reduced by limiting total transport demand. Although demographic trends will put an upward pressure on total demand for transport, the increase in total demand can be limited or even reversed through a reduction of transport demand per person as a result of societal trends, such as a generalization of teleworking, and better spatial planning. Societal trends and the evolution towards "Mobility as a Service (MaaS), facilitated by digital applications, can also increase vehicle occupancy significantly. In this context, autonomous vehicles combined with shared mobility also contributes to increasing vehicle occupancy and thereby decreasing vehicle kilometers, while "empty" kilometers by (autonomous) vehicles could be minimized as much as possible.

As for freight transport, the demand can be limited through stimulating a more local and circular economy. Furthermore, logistics developments allow for an increased load factor whereby demand is met with lesser kilometers driven by vehicles.

Modal shift

Shifting to more efficient and environmentally friendly modes, in particular public transport and active modes, can significantly reduce energy demand and GHG emissions. This shift also be facilitated by the evolution towards “Mobility as a Service” and the increased focus on multi-modality. To accommodate commuters working further away from public transport stations, a combination of public transport with shared active or light electric vehicles (e-bikes, electric steps, …) provide an alternative to individual transport.

[Active modes] Changing lifestyles, for instance resulting from an increasing awareness of the health benefits of a more active modes, combined with the availability of safe infrastructure, could enable a shift to more active modes of transport, such as cycling and walking. In order to facilitate this shift, the attractiveness of soft transport modes need to be improved by developing more safe infrastructure for soft transport modes and taking into account the needs of cyclists and pedestrians when designing or renewing transport infrastructure.

[Public transport] World-class, well-integrated public transport can make mass transit an attractive alternative. Also, the break-through of semi-active modes, such as e-bikes and electric steps can further facilitate the shift towards these softer transport modes. For longer distances, and in particular within and between urbanized regions and their agglomerations, a shift to public transport has the potential to significantly reduce the GHG intensity of distances traveled. In order to make it an attractive option, public transport services are reliable, well-integrated and of high quality[9]. Also, attention could be given to accommodate the needs of travelers in order to give public transport a competitive edge over individual modes, as being the more time-efficient option. Within urbanized areas, separate lanes for buses and trams, as well as a reduction of congestion by reducing the presence of individual vehicles, allow for a more reliable and frequent servicing.

A larger amount of freight can be transported by rail and by inland waterways. Railways is the preferred option for long distance travels, especially from and to sea ports. The use of waterways increases drastically as the infrastructure is currently underutilized and faces almost no congestion and allows for delivery in or very close to city centers. In cities, last mile transport is organized through new logistic models based on light and active modes.

Technology switch

Finally, the third category of options relate to the improvement of the GHG efficiency of transport. Firstly, the energy efficiency of vehicles can be significantly increased, including through reduced weight. Then, the remaining cars can be mostly electric battery or fuel cells vehicles, while a well-developed network of charging points is developed. Buses, trucks, boats and planes can be powered by electricity, hydrogen, e-fuels or biofuels.

[9] Frequent delays, service interruptions and poor quality infrastructure undermine the image of public transport as a reliable alternative for individual modes.

3.2.4 Strategic workstreams

T.1) Long-term vision on mobility

A long-term vision on mobility embedded within a broader reflection on spatial planning should be drafted. This vision should lead to the adoption of an inter-federal mobility plan and also be the basis for a cooperation agreement between the different Belgian entities. This agreement should at least include (i) an integrated multimodal transport system and a strategy for promoting and regulating alternative fuels, (ii) a specific part dedicated to passenger transport and a specific part dedicated to freight transport and (iii) the integration of all aspects related to a just and equitable transition.

T.2) Investment plans and financing strategy for public and active transport modes

Investments in public and active transport modes need to be planned at an early stage, especially infrastructure investments. A plan for developing **public transport infrastructure**, including a rail transport investment plan towards 2050, is required[10,11]. In combination with public transport, a plan for the investments required to integrate **soft transport modes** (incl. bicycle highways) and multimodality (incl. shared mobility) should be developed. Spatial planning should be organized so as to favour the use of public transport.

T.3) Alignment of economic instruments with the long term objectives

Economic instruments should be implemented in order to progressively internalize climate change, congestion, air pollution and other external costs of transport via, a.o., carbon pricing and road pricing. This includes the gradual phasing out of fossil fuel subsidies (incl. revisiting the fiscal treatment of company cars), as well as the alignment of taxes on international aviation and maritime transport.

T.4) Framework for the development of new transport models

It is critical to support and manage (control) the development of new transport models (e.g. "**mobility as a service (MAAS)**", including bikes, speedelec, etc. and sharing) as well as to manage the impact of digitalization and automation (including risks such as significant 'empty kilometres'). In this context, the integration of **new logistic models**, such as the development of city distribution centers on the outskirts of the city and the integration of cargo bikes, electric vans and drones, must be anticipated. A framework to enable this should be developed.

T.5) Promoting freight transport technological developments

Significant steps in RD&D are needed for the development and the deployment of decarbonized fuels as well as of vehicle technologies such as batteries fuel cells and hydrogen gas engines, in order to have viable alternatives for long-haul trucks, coaches, aviation and shipping, both on inland waterways and sea shipping. The deployment of these technologies will require the appropriate infrastructure. A framework for such a deployment need to be developed at the national level.

[10] Together with the need to improve regional (EU) public transport infrastructure.

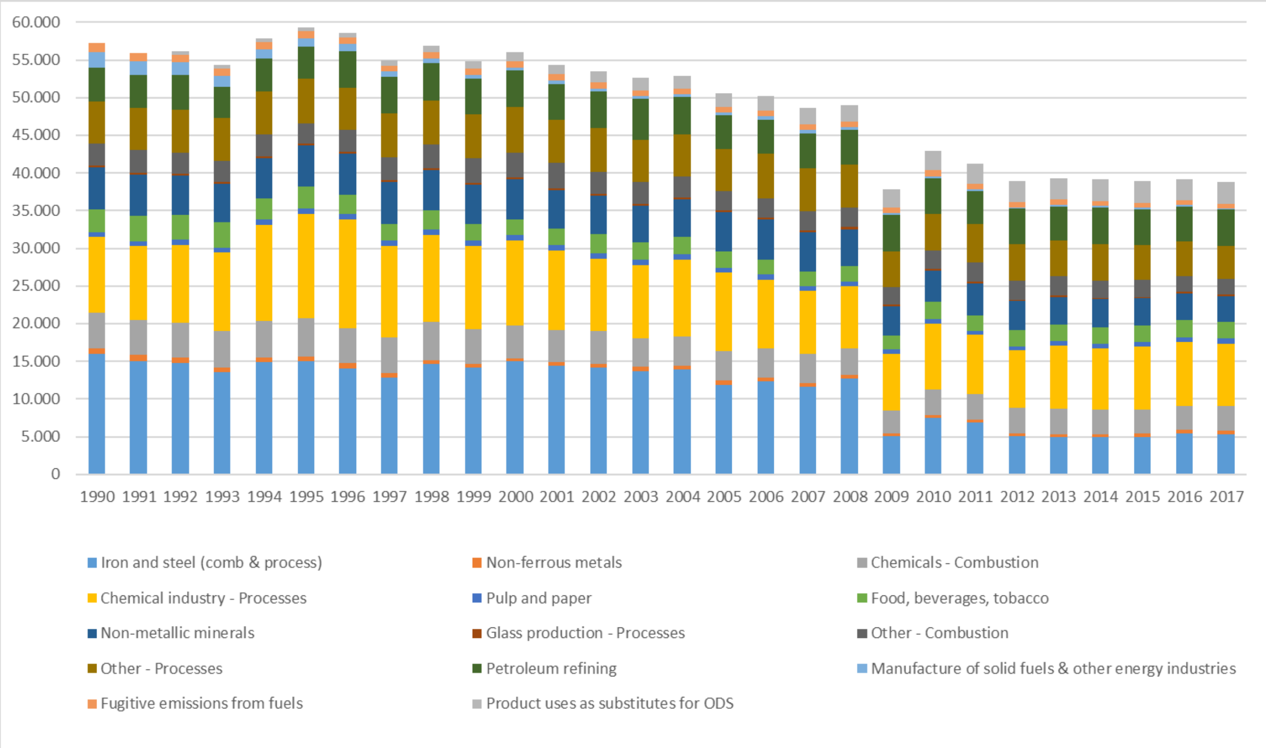
[11] The Federal Energy and Climate Plan foresees 35 billion € investment for rail passenger transport and 1,1 billion € for rail freight transport up to 2030.

3.3 Industry

3.3.1 Where we are

The industry sector accounted for about 34% of total GHG emissions in 2017. It has already considerably reduced its GHG emissions (both combustion and processes) over the past years, even though emission levels seem to have stabilized from 2012 onwards (see figure 6). When compared with 1990, total industrial GHG emissions decreased by around 32%, and by around 23% when compared with 2005.

Figure 6 : Overview of GHG emissions in industry, 1990-2017
(in ktCO2e)



Source: NIR 2019

In 2017, around 30% of total industrial GHG emissions originated from the chemical industry (emissions from combustion and processes), followed by emissions (combustion and process) from other industries with around 17% (including combustion emissions in the textile and leather industry, the construction industry and the wood industry, and process emissions in the cement, lime, metal industry, the electronics industry, other product manufacture, etc.), emissions from the iron and steel industry (14%), the petroleum refining industry (12%), the non-metallic minerals industry (9%), product uses as substitutes for ODS (7%), and the food, beverages and tobacco industry (6%). Other 2017 industrial emissions stem from the pulp and paper industry (2%), fugitive emissions (2%), and the non-ferrous metals industry (1%). Process emissions amounted to 57% of total industrial GHG emissions in Belgium in 2017 (see Figure A4 in the appendix).

As to the evolution of GHG emissions in the different industrial sectors in the 1990-2017 period, the chemical industry reduced its GHG emissions mainly thanks to a more rational energy consumption (leading to a decrease of emissions from combustion of energy). In the iron and steel industry, emissions from energy combustion decreased thanks to a decreased consumption that was the result of a significant switch to the use of electric furnaces (the share of installations using electricity increased from 9% in 1990 to 35% in 2011) and overall emissions also decreased from 2009 onwards due to the economic crisis. In the petroleum refining sector, emissions have been more fluctuating in function of the general economic context as well as temporary shutdowns due to inspection, maintenance and retrofitting.

When we look at projected levels of emissions with current policies by 2030 in the context of the National Energy and Climate Plan, emissions are set to reach a reduction of 27% compared to 1990. With the additional policies and measures adopted in the Plan, emissions in the industry sector would reach a 32% reduction compared to 1990.

3.3.2 Vision

By 2050, in the context of a climate neutral European Union, the Belgian industry will have to reduce its GHG emissions deeply. As an indicative orientation, the reduction could amount to at least 90% with respect to 1990, i.e. at least 85% with respect to 2017 (BECCS related emission reductions not included). The remaining emissions would be compensated by negative emissions, including, possibly, via the use of BECCS techniques in the industry itself.

[Circular economy] In a European and global context, new business models almost fully based on a circular economy allow to maximize the value of materials while drastically reducing the consumption of raw materials. Competitiveness of Belgian industries has been enhanced through the development and production of high value, long lasting goods supported by new consumption modes.

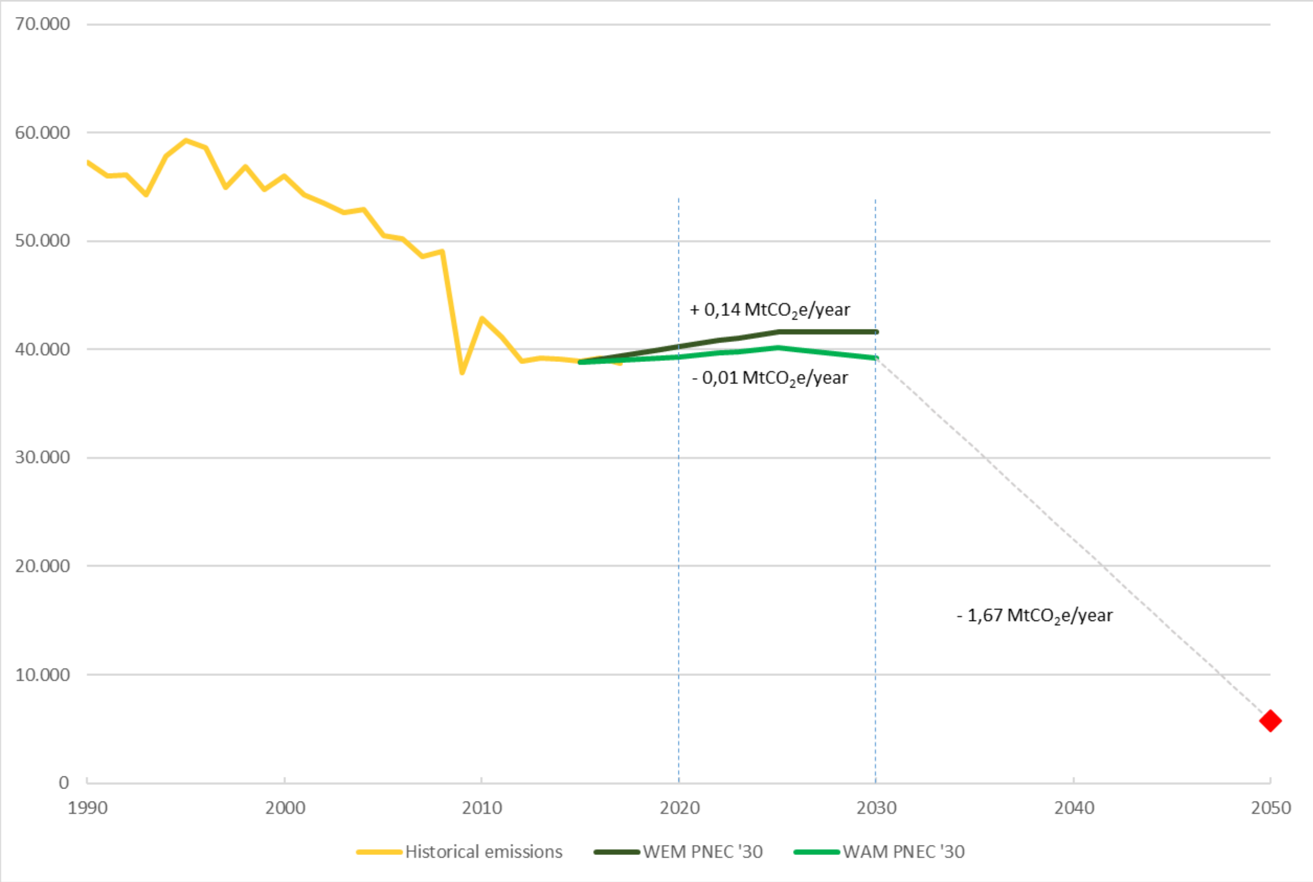
[Energy efficiency and new technologies and feedstocks] Belgian industries have significantly reduced their energy consumption and new industrial processes are in place that are based on renewable energy, circular feedstock, biomass and CCU.

[Industrial symbiosis] Companies are working narrowly together in the value chain and industrial symbiosis between companies and with other sectors such as buildings, energy production and agriculture is implemented on a large scale and enhances the circularity of the resources (heat, water, materials, etc.).

Figure 7 illustrates the historical emissions and the projected emissions up to 2030 with existing measures (WEM) and with additional measures (WAM) as foreseen in the National Energy and Climate Plan (NECP). The emissions corresponding with a deep decarbonization level by 2050 is also depicted. It shows that, if the measures foreseen in the NECP effectively deliver the expected emission reductions by 2030, the average annual emission reduction effort in the period 2030-2050 will have to increase very significantly with respect to its level in the period 2020-2030 under the current 2030 ambition level.

Figure 7 : Historical emissions and projections in industry, in relation to 2050 emissions corresponding with a deep decarbonisation level

(in $ktCO_2e$)



Sources: NIR 2019, NCEP, own calculations, BE 2050 net zero study

3.3.3 Levers

Circular economy levers

The first set of levers relate to the **demand for products** that can be significantly reduced by the deployment of the sharing economy, product lifetime extension and reparability. Material switch towards more sustainable materials and material efficiency (use of a lower quantity of materials in a product) allow for further drastic reduction in product demand, although not necessarily in product value since these require new technical developments, new business models and potentially longer value chains. Materials can also be recovered from end of life products. These levers play a key role for materials and the related emissions in the buildings (renovation and new built) and transport (number of vehicles) sectors, as well as for appliances.

Competitiveness aspects are key in such a new industrial context, meaning that a reduction (vs a business-as-usual scenario) in the product demand in Belgium does not necessarily imply a similar reduction in **production volumes** in Belgium, even when the EU and the other major commercial partners engage in a similar transition pathway. In this respect, any further improvement of the competitiveness of Belgian industries is to be fully supported, together with the need to (almost) fully decarbonize each sector in the long term.

Decarbonization of industrial processes

At present, Belgian industries are among the most efficient in the EU, while a competitive resource-efficient and circular economy will need to be developed to maintain this position in the future. Further significant energy needs and process emissions reductions will need to be obtained when producing industrial material (e.g. glass, steel, plastics), in particular through higher recycling rates and new material use (cf. above), but also through other means. can significantly reduce energy-related and process emissions in the different industrial sectors

Continuous **energy efficiency improvements** can be ensured for each material production technology, so as to limit energy needs as much as possible.

Secondly, a **switch to innovative low carbon processes** can significantly reduce energy-related and process emissions in the different industrial sectors. It is expected that technologies that are already known will demonstrate their viability at larger scale in the coming years and that RD&D can significantly reduce the cost of breakthrough technologies.

Thirdly, a combination of electrification, the increased use of sustainable biomass and of renewable hydrogen and synthetic gas can reduce energy-related emissions (**fuel switch**), whereas renewable hydrogen and sustainable biomass can be used as feedstock for a number of industrial processes (e.g. steel production, certain chemicals – **feedstock switch**).

Next, given that some industrial emissions will be hard to eliminate, carbon capture and storage will be necessary to keep them out of the atmosphere. Carbon capture and storage could even be applied when biomass is used, thereby providing negative emissions (BECCS).[12]

Finally, several levers exist at EU level[13] to phase out the consumption and production of fluorinated gases (F gases) as substitute for **Ozone Depleting Substances** (ODS) in the coming years and up to 2050 (in particular related to refrigeration and air conditioning technologies), including licensing systems (imports/exports), imposing containment and recovery, training and certification of persons handling these gases, labelling, controlling the amounts through a quota system, banning different uses and preventing emissions.

3.3.4 Strategic workstreams

I.1) Industrial roadmaps for competitive, innovative and climate-friendly industries

In close cooperation with the sectors, industrial roadmaps for competitive, innovative and climate-friendly industries should be developed, embedded within the EU's Industrial Strategy, sectoral roadmaps at the EU-level and the EU's policy framework (in particular the EU ETS), taking into account the international context. These roadmaps will provide guidance for the modernization of Belgium's industrial sectors and align the development of our industrial fabric with the transition towards climate neutrality, while identifying the challenges, as well as the opportunities this transition will entail.

12 See also section 4.4, '0.4 Negative emissions'.

13 See EU Regulation N° 517/2014, EU Directive 2006/40/CE on Mobile AC and a set of implementing acts.

Also, due attention should be given to supporting and encouraging industrial clusters and industrial symbiosis, in order to make optimal use of synergies between activities in different sectors. Ambitious roadmaps that provide clear pathways and identify opportunities for innovation and industrial leadership should foster the development of strong, innovative value chains grafted on climate-friendly products and technologies. Based on these roadmaps, a concrete policy framework can then be developed in a coherent and integrated manner, to cost-effectively target RD&I support and to support investment in the necessary infrastructure (for instance regarding pipelines for transporting hydrogen or CO2), while maximizing the use of EU funds.

I.2) Mapping and scaling-up of circular economy strategies and plans

Circular economy plans and strategies should be developed, integrated and scaled-up in Belgium. These should build on already existing initiatives[14] and should (i) include mid-term and long-term material efficiency *targets* for products, (ii) rely on *fiscal policies* in order to stimulate repair, recovery of materials and components, recycling, specific material use and material efficiency and (iii) support the deployment of industrial *symbiosis and clusters* of companies (see also link with workstream on circular economy in the buildings sector). Besides policies targeting products, the development of *a new industry*, directly related to recycling, including collecting, repairing, processing and distribution of products/materials, as well as business model shifts (e.g. product-as-a-service-model), should be supported.

I.3) Electrification: challenges and opportunities for electro-intensive industries

The already important role of electricity in industry will further increase in a decarbonized future. Moreover, the electricity system will increasingly be based on renewable intermittent energy sources. In this context and within the increasingly integrated energy market, it will be essential to fully understand the possible evolutions of electricity prices for industrial actors, to monitor them and to ensure that they are kept under control for competitiveness reasons. It is also necessary to fully understand the interplay between the increasingly intermittent character of energy sources and the industrial sector and clarify the role the industrial sector could play in managing intermittency, through demand-side management and switching to fuels that store intermittent electricity production (e.g. green hydrogen, e-fuels). Finally, careful consideration needs to be given to how to make the best use of industrial heat and/or power generated by heat, within industry or in other sectors of the economy (e.g. buildings, agriculture and energy). A vision and a common framework should be developed that encompasses all these elements.

I.4) Vision and framework for the use of biomass, hydrogen, e-fuels and carbon capture

The potential for the deployment in Belgium of biomass, hydrogen, e-fuels and carbon capture should be assessed, also in the context of the development of the industrial roadmaps. A vision and framework on the use of these technologies will be developed in order to inform policy choices with respect to RD&I and the provision of the necessary infrastructure (pipelines, …). Also, due attention should be given to the supply side of hydrogen and e-fuels (P2), as well as sustainable biomass (A3).

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[14] Such as outcomes from *Vlaanderen Circulair* (a partnership between governments, companies, civil society and the academic world in Flanders that stems from the Flemish 2050 vision, where circular economy was identified as one out of seven transition priorities. This partnership is led by OVAM), the *Plan Régional en Economie Circulaire (PREC)* in Brussels or the *Plan Wallon déchets-ressources* in Wallonia.

I.5) National industrial strategy for a bio-economy

Transitioning to a bio-economy will be essential to become climate neutral. Products from biomass origins will increasingly replace fossil fuel-based products. While the transition to a circular economy can keep fossil fuel-based products in the economy for a longer time, they still cause additional greenhouse gas emissions when they are eventually burned (or landfilled). By contrast, bio-based products are part of the natural carbon cycle: they don't add additional carbon to the atmosphere at the end of their lifetime.

The bio-economy comprises both the supply side of biomass[15], as well as the use of renewable biomass and waste streams. The bio-based economy is the part of the bio-economy which uses biomass and produces bio-based products and materials. A strategy to support the development of a thriving bio-economy in Belgium should therefore also cover the demand side (the bio-based economy), and should in this regard focus on two main axes, namely (i) directing investments towards research, development and innovation of bio-based alternatives, and (ii) supporting the development of value chains built around the bio-economy. This strategy should build on existing strategies[16].

15 See section 3.5 on 'Agriculture, forestry and land use'.

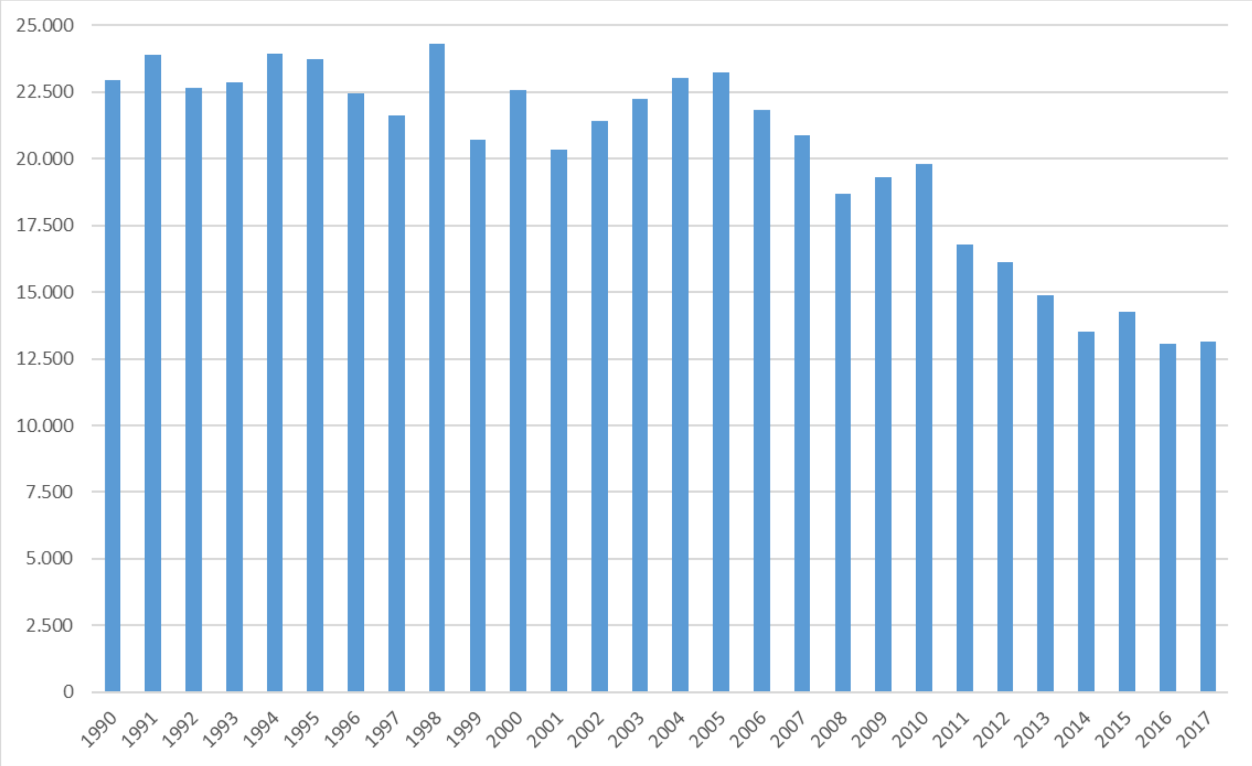
16 Such as the *Vision and strategy for a sustainable and competitive bio-economy in Flanders in 2030* and the A *new bio-economy strategy for a sustainable Europe* for instance.

3.4 Energy production

3.4.1 Where we are

The energy production sector accounted for 11,5% of total GHG emissions in 2017. Figure 8 below shows the evolution of GHG emissions in this sector between 1990 and 2017[17].

Figure 8 : Evolution of GHG emissions in the power sector in the period 1990-2017
(in $ktCO_2e$)



Source: NIR 2019

Total GHG emissions of this sector have decreased between 1990 and 2017, especially since 2005. In 2017, GHG emission reductions reached around 43% when compared to 1990, and almost 44% when compared to 2005. It is worthwhile mentioning that while the production of electricity and heat increased between 1990 and 2017, the related GHG emissions decreased mainly thanks to technological improvements, an increased amount of CHP installations and the shift from use of solid fuels to gaseous fuels and renewable energy sources.

When we look at projected levels of emissions with current policies by 2030 in the context of the National Energy and Climate Plan, emissions are set to reach an increase of around 1,4% compared to 1990. With the additional policies and measures adopted in the Plan, emissions in the power sector would reach a 5,3% increase compared to 1990.

[17] Excluding emissions from waste incineration with energy recuperation, that are included in the waste sector.

3.4.2 Vision

By 2050 at the latest, the Belgian electricity system could be fully decarbonized (100% reduction in GHGs) and could deliver energy coming exclusively from renewable and sustainable domestic power sources as well as international sources through i.a. a highly integrated European electricity network. If needed, the electricity production system will also be able to contribute to reach the required total amount of negative emissions by the use of the BECCS technique. By the end of 2025, the last nuclear power plants are closed and the energy mix is mostly composed of natural gas and renewable energy [Ref. Energy Pact]. The share of fossil fuels in the electricity mix will be systematically scaled down and completely phased out by 2050 [Ref. Energy Pact]. By 2030, the renewable production mix will consist of around 8GW solar energy, 4,2GW onshore wind energy and 4GW offshore energy [Ref. Energy Pact].

[Decentralization] In order to manage the increased total electricity demand and to secure the energy transition, the energy model has progressively evolved from a centralized, demand-driven model to a more decentralized, supply-driven model with an important role for citizens in demand-side management, renewable production and storage.

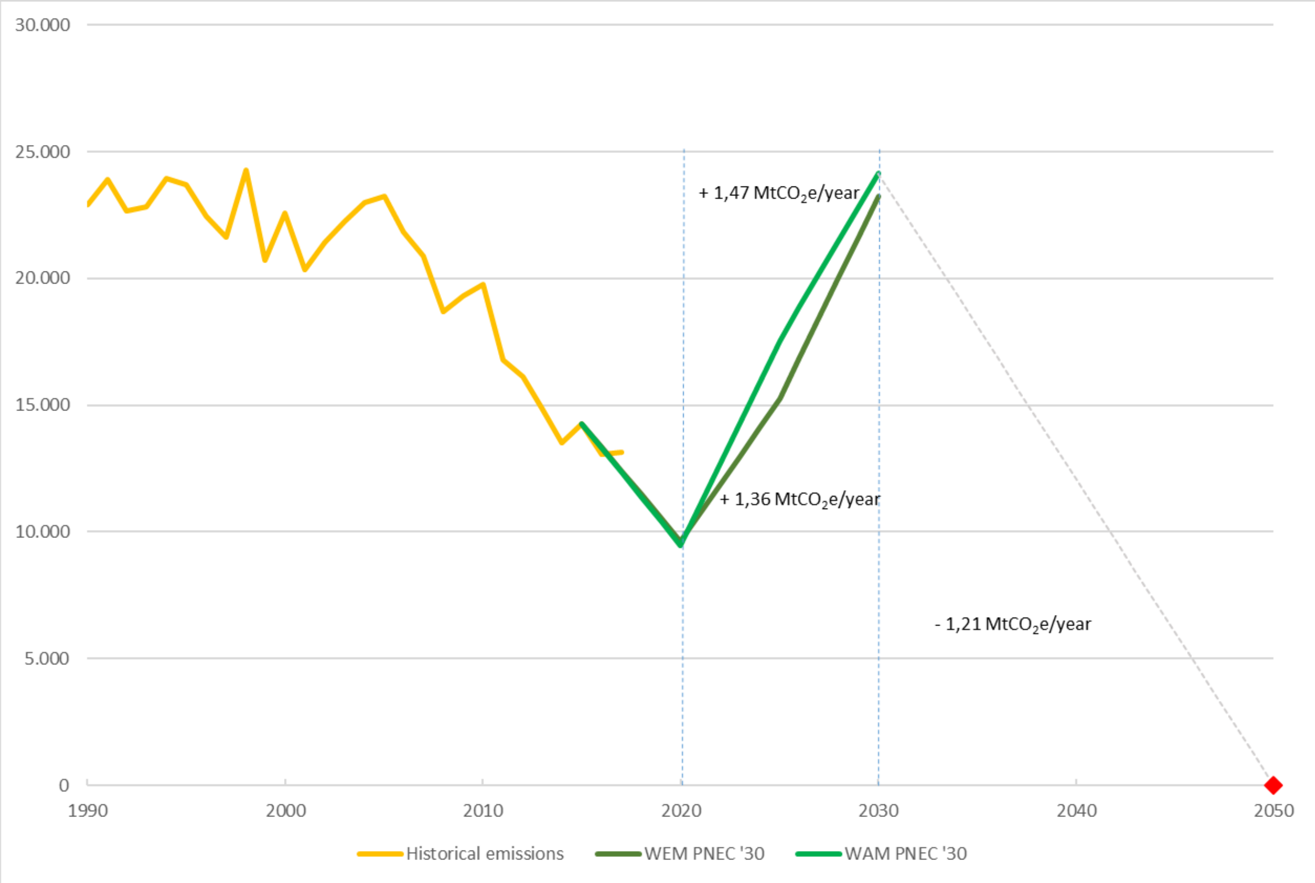
[Intermittency] The reliability of the system is ensured through (i) efficient grid management, (ii) improved storage capacities and (iii) several other flexibilities. The integration of renewable energy is indeed guaranteed through decentralized and large-scale storage, different types of demand response and gas-fired power plants fuelled by synthetic gas or biogas. When economically viable and in order to ensure better storage, periodic surpluses of produced renewable electricity are used to transform power into heat, hydrogen or other energy carriers.

[Storage and DSM] The industrial storage capacity will reach around 2GW by 2030. Residential storage, storage in SMEs, electric vehicles in storage mode or local tools will reach a total capacity of around 1,5GW by 2030. The demand volume that can be shifted in one and the same day will reach around 1,5 GWh in total. These plans will not be implemented in a linear way between 2020 and 2030, but will be introduced at a higher speed from 2025 onwards. By then, between 30% to 40% of the storage and demand management objective (demand that can be shifted) will have been reached.[Ref. Energy Pact]

Figure 9 illustrates the historical emissions and the projected emissions up to 2030 with existing measures (WEM) and with additional measures (WAM) as foreseen in the National Energy and Climate Plan (NECP). The emissions level corresponding with full decarbonization by 2050 is also depicted. It shows that, if the measures foreseen in the NECP effectively deliver the expected emission increases by 2030, the average annual emission reduction effort in the period 2030-2050 will have to amount to about 1,21 MtCO_2e.

Figure 9 : Historical emissions and projections[18] in the power sector, in relation to the emissions level corresponding with full decarbonisation by 2050

(in $ktCO_2e$)



Sources: NIR 2019, NCEP, own calculations, BE 2050 Net-zero study

3.4.3 Levers

Electricity mix

The domestic deployment of renewable electricity can be drastically increased, in particular solar, and onshore and offshore wind, but also deep geothermal energy. The renewable production system can also consist of CHP installations based on biomass and biogas [Ref. Energy Pact]. This mix must be determined in accordance with the needs for flexible capacity.

Electricity imports/dependency

A significant level of net imports could be available via the fully integrated EU electricity market, and can be used if needed and depending on market conditions. The already well-developed **interconnections** with neighbouring systems can be further enhanced, also in order to manage intermittency.

[18] Own assumptions were made regarding the projected evolution of public electricity and heat production through waste incineration, given that this level of detail cannot be found in the publicly available projections. This has an impact on the projected emissions of the overall category 'public electricity and heat production' given that the projected emissions from waste incineration with recuperation of energy are deducted from the total of the overall category.

Intermittency management

Local **distribution networks** are to be developed in order to fully exploit the potential of renewable energy. A continuous development of new **centralized and decentralized storage systems** must be guaranteed, involving the industry, as well as SMEs and households through storage in electric vehicles and local tools.

Hydrogen, e-fuels and biomass

Hydrogen, e-fuels and biomass will play an important role in every energy demand sector (industry, transport, buildings), as well as a feedstock for certain industrials processes.

As regards the supply of hydrogen and e-fuels, electrolysers [and other e-fuels units] are conceived and built in such a way that they need not be operational on a continuous basis, but interact with the electricity system by producing when electricity supply is abundant and exceeds demand, thereby contributing to grid stability and fostering the integration of intermittent renewable energy sources.

The use of hydrogen and e-fuels, produced from electricity, in end use sectors then acts as implicit electricity storage, as these fuels are produced at times of abundant electricity supply and stored for later use. Furthermore, hydrogen and e-fuels can also play a role as explicit storage (chemical storage), when they are used by the power system to produce electricity at a later point in time.

In order to guarantee carbon neutral nature of e-fuels, the carbon used in e-fuels must originate from sustainable biomass or direct air capture. When carbon from fossil fuels would be used, they need to be captured at the end of their lifecycle in order to avoid additional greenhouse gas emissions. A clear monitoring and accounting framework should therefore be developed in order to guarantee the carbon neutrality over the lifecycle of these fuels.

Besides domestic production, it might be considered to import hydrogen and e-fuels from regions where they can be produced more cheaply. Import could also be significant when the transport infrastructure, for example via ships, is further developed. In all cases, networks for hydrogen are further extended and developed, while gas grids on high and medium pressure will be progressively used to transport and deliver renewable gas (biogas, synthetic gas, hydrogen if possible). To this end, the necessary adjustments to the grids will be made, while specific infrastructure will be provided, when necessary.

The supply of biomass is closely linked to agriculture and land use sector. Also, the necessary infrastructure to process biomass into biofuels and biogas must be developed in due time.

3.4.4 Strategic workstreams

P.1) Long term vision on electricity supply

Electricity will play an increasingly important role, as many energy end uses will be directly (for instance by driving electric cars or the use of heat pumps) or indirectly electrified (via the use of hydrogen and e-fuels, produced with electricity). A stable policy framework is needed to ensure generation adequacy in the most cost-effective manner, whilst avoiding market disruptions and investment in stranded assets. This policy framework is inherently embedded within the European single energy market. Together with our neighbouring countries, a long-term vision for a 100% renewable electricity supply should be developed, which assesses generation adequacy from a regional perspective, taken into account differences regarding low-cost electricity generation potentials and the cost-effectiveness of net electricity imports, vis-à-vis domestic power generation.

The development of this vision should build on, a.o., the following elements: (i) full exploitation of the potential of domestic renewable resources, complemented with renewable energy sourced from abroad through interconnections, (ii) full exploitation of the value of the system through digitalization and enhanced market design (including smarter grids), and (iii) ensuring the reliability of the energy system through an energy mix that can meet demand at all times.[19]

P.2) Green hydrogen and e-fuels production and infrastructure

Due to the importance of hydrogen and e-fuels as energy carriers for hard to decarbonize end uses and as feedstock for industrial processes, it is essential to guarantee a sufficient and cost-effective supply of these fuels. Belgium has the world's largest hydrogen network and is therefore in an excellent position to reap the competitive advantages that the development of green hydrogen entails. Some analyses on the role of such fuels are available at international, European and regional levels[20]. Still, a strategy for green hydrogen and e-fuels needs to be developed, in order to give impetus to research, development and innovation efforts focused on the production of hydrogen and e-fuels, and to support the development of value chains related to the production of these fuels. The strategy should also assess which infrastructures are needed for the distribution of these fuels, based on projections regarding production and consumption of these fuels in climate neutral scenarios.

P.3) Long-term framework for the integration of intermittent sources by all actors

It is important to plan ahead and develop the energy market and energy infrastructure for accommodating an increasing share of intermittent energy sources. Balancing electricity grids to ensure grid stability takes place in a regional and European context, within the single European energy market, as energy markets are increasingly integrated. A clear framework for the integration of the increasing share of intermittent energy sources is needed which support the establishment of a smart grid with the activation of the demand side (incl. shifting to dynamic prices and developing DSM), sector coupling through the electrification of the housing and transport sectors and the built-up of storage capacities. Also, the role of hydrogen and e-fuels as implicit and explicit electricity storage will be taken into account. Finally, the role of industrial actors (see I.4), other companies (incl. SMEs) and citizens will further be strengthened, as they will become ever more active players in the energy market.

P.4) Support to the active role of citizens

The energy system will develop from a centralized system in which supply mainly follows caters closely to demand fluctuations to a smart and decentralized power system, with a more active demand side. A strategy should assess how to further enable citizens to play an active role in energy production (as prosumers, in the framework of energy communities, through renewable energy cooperatives, …) and energy consumption (by building up storage, actively managing their demand as a response to dynamic prices, …).

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[19] See for instance the Energy Pact as well as Elia's studies and views on the Belgian energy transition from 2017 (see "Elia's kijk op de Belgische energievisie voor 2050" (June 2017) and "Electricity scenarios for Belgium towards 2050" (November 2017)).

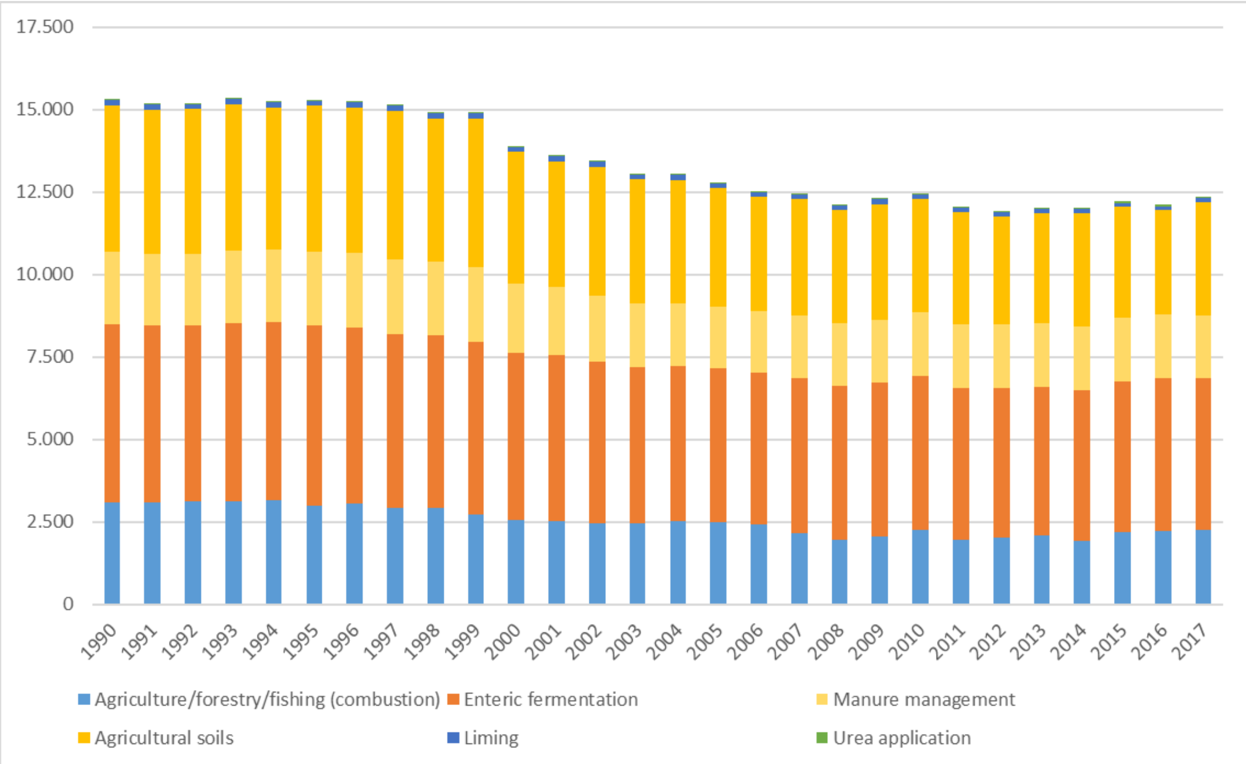
[20] See for instance IRENA (2018), Hydrogen from renewable power; IEA (2019), The future of hydrogen; Fuel Cells and Hydrogen 2 Joint Undertaking (2018) Hydrogen roadmap Europe; TWEED (2018), Roadmap hydrogène pour la Wallonie; VEA (2018), Het potentieel voor groene waterstof in Vlaanderen: Een routekaart ; Hydrogenics et al. (2016), Power to gas roadmap for Flanders.

3.5 Agriculture, forestry and land use

3.5.1 Where we are

Figure 10 below presents the evolution of GHG emissions in the agriculture sector between 1990 and 2017. In 2017, total agricultural emissions have decreased by 19% when compared to 1990, and by 3% when compared to 2005.

Figure 10 : GHG emissions in the agriculture sector between 1990 and 2017
(in $ktCO_2e$)



Sources: NIR 2019

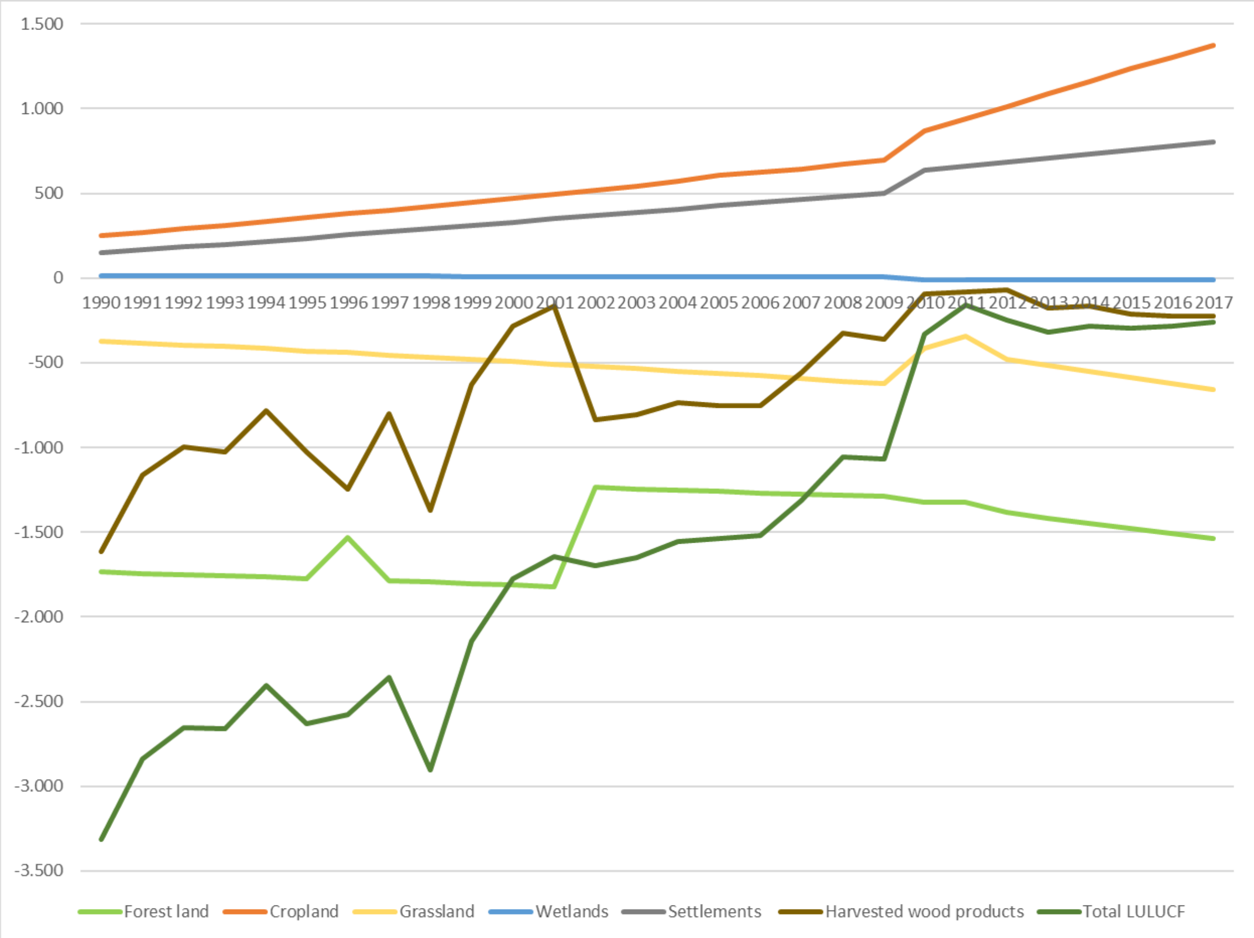
The largest share of emissions in this sector in 2017 stemmed from enteric fermentation (37%), agricultural soils (28%), emissions from combustion (18%) and manure management (16%).

The main drivers of the evolution of GHG emissions in the agriculture sector between 1990 and 2017 include (i) the decrease and changed composition of livestock, as well as the reduced use of mineral and organic fertilizers (non-CO2 emissions), and (ii) a switch from diesel to gas in the horticulture sector.

When we look at projected levels of emissions with current policies by 2030 in the context of the National Energy and Climate Plan, emissions are set to reach a reduction of 26% compared to 1990. With the additional policies and measures adopted in the Plan, emissions in the agriculture sector would reach a 35% reduction compared to 1990.

As regards the LULUCF (Land Use, Land Use Change and Forestry) sector, the net removal capacity of the sector has decreased considerably between 1990 and 2017 (see Figure 11). Indeed, in 2017, the net removal capacity was 92% lower than in 1990, and 83% lower than in 2005. This is mainly due to the bigger increase in emissions from cropland and settlements than the increase in removals from forests and grasslands.

Figure 11 : Evolution of emissions/removals in the LULUCF sector between 1990 and 2017
(in $ktCO_2e$)



Source: NIR 2019

When we look at projected levels of emissions/removals with current policies by 2030 in the context of the National Energy and Climate Plan, we observe that removals are set to reach a reduction of 63% compared to 1990. With the additional policies and measures adopted in the Plan, the same levels are projected to be reached.

3.5.2 Vision

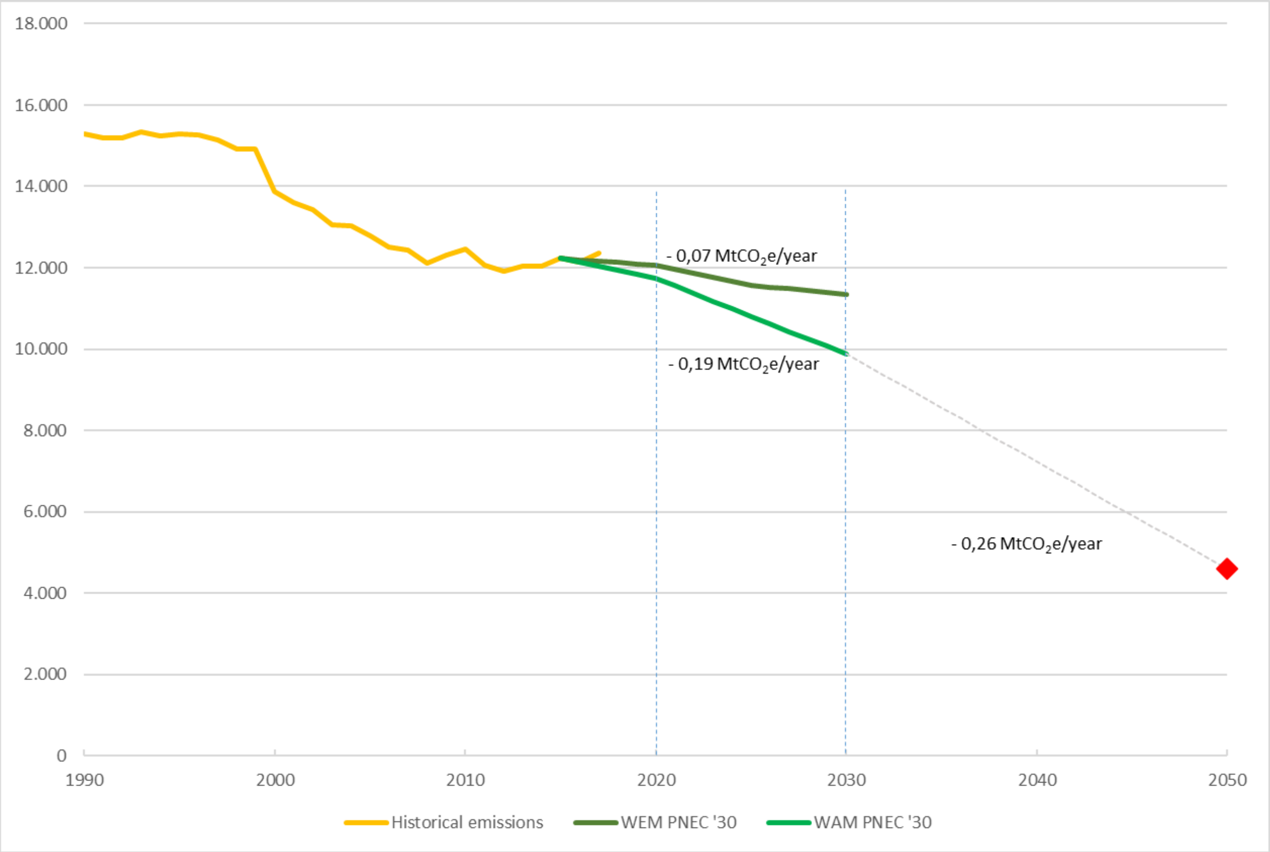
By 2050, the agriculture sector will have to reduce its emissions significantly. As an indicative orientation, the reduction could amount to at least 70% with respect to 1990 (i.e. 63% with respect to 2017) and the carbon sequestered by soils and forests could be increased by between 4 to 5 MtCO2e, about 3% of total GHG emissions in 1990.

[Food consumption] Diets have evolved and the share of animal proteins has fallen in favour of vegetable-based proteins. By 2050, **food consumption** (in kcal/cap/day) has decreased to at least the level recommended by the Supreme Council of Health[21] or even further. The share of **meat consumption** in total food consumption is divided by a factor of 2 to 4. **Food waste** is reduced to a maximum. Food packaging has also been reduced and short circuits allow to significantly reduce the transport demand for these goods.

[Agriculture] By 2050, agriculture has moved towards a much less intensive production model. Carbon sequestration in soils has significantly increased as a result of improved agricultural practices and emissions from livestock farming have been significantly reduced though a combination of measures. Greenhouse horticulture relies only on renewable energy sources.

[Forestry and land] By 2050, natural forests are effectively protected and other forests are managed sustainably (balance between growth and harvest, permanent or even growing carbon stock in biomass and soil). Deforestation is avoided, and where it is unavoidable, it is compensated with new forests elsewhere. Natural sinks, including reforestation and the development of natural prairies, are further developed in order to significantly contribute to negative emissions.

Figure 12 : Historical emissions and projections in the agriculture sector, in relation to an emissions level corresponding with full dercarbonisation of energy related emissions and very large reductions of non-CO_2 emissions by 2050 (in $ktCO_2e$)



Sources: NIR 2019, NCEP, own calculations, BE 2050 Net-zero study

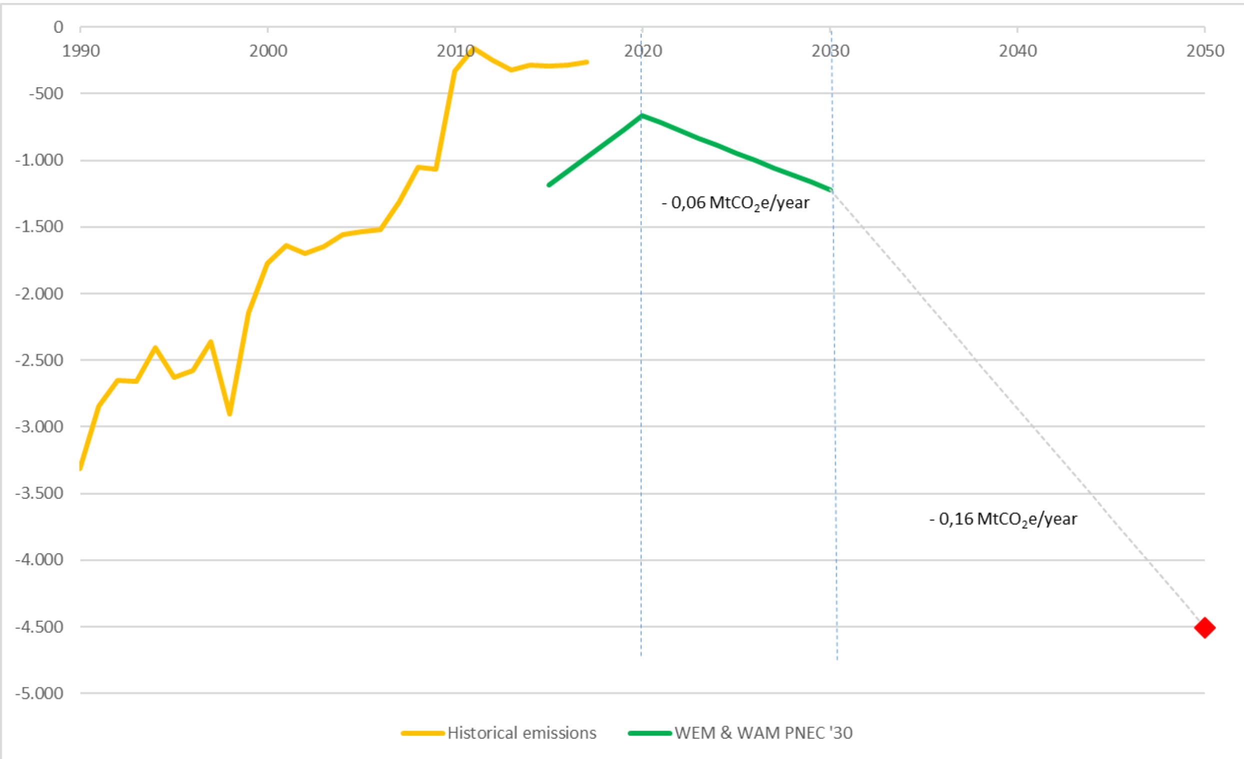
[21] Nutritional recommendations for Belgium – 2016 (Supreme Council of Health) (https://www.health.belgium.be/sites/default/files/uploads/fields/fpshealth_theme_file/hgr_9285_avis_voedingsaanbev.pdf)

Figure 12 illustrates, for the agriculture sector, the historical emissions and the projected emissions up to 2030 with existing measures (WEM) and with additional measures (WAM) as foreseen in the National Energy and Climate Plan (NECP). The emissions level corresponding with full decarbonisation of energy related emissions and very large reductions of non-CO_2 emissions by 2050 is also depicted. It shows that, if the measures foreseen in the NECP effectively deliver the expected emission reductions by 2030, the average annual emission reduction effort in the period 2030-2050 will have to increase by 42% with respect to its level in the period 2020-2030 under the current 2030 ambition level.

Figure 13 illustrates, for the LULUCF sector, the historical emissions and the projected emissions up to 2030 with existing measures (WEM) and with additional measures (WAM) as foreseen in the National Energy and Climate Plan (NECP). A (negative) emission level corresponding to the level required to compensate for remaining emissions by 2050 is also depicted. It shows that, if the measures foreseen in the NECP effectively deliver the expected absorptions by 2030, the average annual emission absorption effort in the period 2030-2050 will have to increase by about 200% with respect to its level in the period 2020-2030 under the current 2030 ambition level.

Figure 13 : Historical (negative) emissions and projections in the LULUCF sector, in relation to natural sinks needed by 2050 to compensate for remaining emissions

(in $ktCO_2e$)



Sources: NIR 2019, NCEP, own calculations, BE 2050 Net-zero study

3.5.3 Levers

Food and diets

Reducing waste and dietary changes can free up large amounts of land, within as well as outside of Belgium. In particular, reducing meat consumption and production would not only reduce animals' direct GHG emissions but would also require less production of feed, freeing up land for other agricultural products or land use, as well as reducing indirect land use emissions in third countries, as feed imports can be reduced significantly.

Agriculture

[Livestock] A change in consumer's diet away from animal proteins to vegetable protein can lead to a significant decrease of livestock and the associated direct and indirect GHG emissions. Since agriculture in Belgium is an export-oriented sector, emissions reductions on the Belgian territory will depend on (i) the evolution of consumption patterns worldwide, (ii) the degree of competitiveness of the sector in Belgium and (iii) the degree in which the agricultural model in Belgium evolves towards a less intensive model.

[Animal feeding] Better **feed management** can reduce enteric emissions from cattle in the first phase. Further emission reductions can be obtained through selection of animals. Feed for animals can also stem from **alternative sources of proteins** (algae, insects, etc.), thereby reducing demand for traditional feed.

[Agricultural practices] **Agroforestry** can become the standard practice. Potential negative impacts on yields can be compensated by reduced food consumption and waste. Entrants (pesticides, and phosphor, potash and N2O fertilizers) can be progressively phased out. Pasture grazing intensity would then be significantly reduced and manure management (all types) would evolve towards a higher share for pasture manure in particular.

[Greenhouses] Companies in the greenhouse horticultural sector have already transitioned from oil to gas as energy vector. The next, gradual evolution is the shift towards renewable energy sources.

Forestry and land

Land is a scarce and finite good, used for and its use is divided between settlements, agricultural land, forests and natural habitats. The forest and land use sector plays a central role in the natural carbon cycle by continuously exchanging carbon with the atmosphere through natural processes. Unlike most other sectors, the land and forestry sector can act as a net carbon sink, sequestering over a given period more carbon than it emits as greenhouse gas over a given period.

[Forests] Afforestation, reforestation and forest management are key for land use emissions. By increasing the amount of land covered by forests, additional carbon stocks are built up, effectively providing for negative emissions.

[Soil organic carbon] A lower demand for land for food and feed production, resulting from a reduction in demand for food and feed and/or efficiency improvements can free up agricultural land for other uses. When converting cropland to forest land, large amounts of CO2 can be sequestered in the forest soil and the living biomass, (trees), resulting in negative emissions over a certain period. Freed up land, for example as a result of densification or a reduction of the need for agricultural land , can be used for afforestation or reforestation.

The restoration of existing forests can help to restore carbon stocks. Forests move in the long term to a balanced state in which emissions and removals level out. Smarter forest management practices, increasing the carbon density with other tree species and optimizing harvests can all be considered to optimize the forest carbon sink. At the same time, forests are important as a source of biomass, used for energy and material substitution, in the context of the development towards a bio-economy. An optimal balance needs to be found to maximize the carbon stock of the forest, while preserving an important supply of biomass, taking into account potential negative impacts on biodiversity, water supply, etc.

[Soil organic carbon] Soil organic carbon in other land categories also plays a role. Conversion of permanent grasslands will be limited as much as possible, while freed up land that is not used for afforestation, will be used to restore permanent grasslands, whenever possible. Peatland restoration is prioritized to enable important carbon sinks. Regarding cropland, soil degradation is slowed down and carbon sequestration is enhanced, which increases soil fertility and productivity. An optimal amount of soil organic content is pursued, taking into account the various functions of the soil.

3.5.4 Strategic workstreams

A.1) Vision for a sustainable agriculture

The agricultural sector can and will play a positive role in climate mitigation, adaptation and the attainment of other Sustainable Development Goals, in particular the protection and increase of biodiversity. Transitioning to a more sustainable agricultural model, should take into account the difficult financial situation a lot of farmers find themselves in. Government support, in particular via the Common Agricultural Policy, should ensure a fair income, in particular for small-scale farmers, but should be directed to farmers that are producing in an environmentally sustainable manner, and thereby contributing to climate and environment objectives. The need for a climate-friendly and environmentally beneficial agricultural sector should be reflected in Belgium's CAP Strategic Plan. To support farmers to transition towards more sustainable farming systems, a significant part of Belgium's budget under the first pillar of the CAP should be ring-fenced for eco-schemes.

A comprehensive vision for a future-proof agricultural sector should be developed, to encourage the take-up of low-carbon farming practices and allow for transformational change in land use. This vision should identify important areas for further research and innovation into environmentally-friendly agricultural models, set out the orientations for competitive and fair remuneration mechanisms for farmers, in particular through exploiting new business opportunities related to the bio-economy and the provision of public goods, provide guidance for pro-active consumer-focused policies to support a shift towards healthier diets and give impetus to a policy framework aimed at reducing food waste throughout the supply chain and at the level of the final consumer. R&D, testing and demonstration of measures to improve agricultural productivity. This vision should be inspired by existing visions or strategies in Belgium[22].

A.2) Role of carbon sinks in reaching negative emissions in Belgium

An assessment of the exact potential of additional carbon sinks in Belgium and a strategy to tap into this potential is required, while taking into account the vision for a sustainable agriculture (see A.1 above), the need to preserve and enhance biodiversity (see A.4) and the biomass supply requirement (including for the bio-economy, see A.3).[23]

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[22] Such as ILVO's "*2020 & beyond Vision statement on research for efficient and sustainable agricultural and food production"* and the Walloon region's "*Plan stratégique 2020 pour le développement de l'agriculture biologique en Wallonie"*.

[23] As regards the natural carbon sink, we also need further work on untangling the additional anthropogenic impacts on the carbon sink from the natural level of the sink, stemming from natural and land-specific

A.3) Strategy for a bio-economy: supply side

Transitioning to a bio-economy will be essential to become climate neutral. Biomass will be increasingly used for energy production, as well as to produce bio-based products replacing fossil-fuel based materials (for example as construction material or for bio-plastics). It is important to optimize the supply of biomass in a sustainable manner. First of all, industrial and municipal waste, as well as forest and agriculture residues should be valorised. Also, the cascade use of biomass will play an important role, in the context of a circular economy in which as much value as possible is extracted from all inputs and products. For example, wood can first be used in construction, and thereafter for energy production. The forestry and land use sector will play an important role as a biomass supplier. Well-managed forests can provide a source of wood, taking into account their other functions (sequestering CO2, biodiversity, soil protection, …). Agricultural land can be used to grow energy crops, in particular fast growing lignocellulosic crops, but we must avoid indirect effects, stemming from a competition for agricultural land with other agriculture commodities.

A bio-economy strategy should look more deeply into the supply side of biomass. This strategy should build on existing strategies[24], analyse the potential for sustainable biomass production in Belgium, assess the economic benefits and opportunities for farmers and land owners and propose policies and measures to support the sector in tapping into these new revenue streams, and establish a framework for sustainable imports to avoid displacing our emissions and importing deforestation. In this context, an analysis of the impacts of our imports of biomass and bio-based products is necessary to have a clear view on the environmental and social impacts, and the amount of indirect emissions our consumption entails. On this basis, clear policies and measures, including labelling, norms and quantitative limits, should be considered and implemented, in order to guarantee a genuinely climate-neutral bio-economy.

A.4) Land use and biodiversity

Climate change and biodiversity are intimately interlinked and should be addressed in a coherent and integrated way. The conservation, restoration and sustainable use of biodiversity and ecosystem services is essential for securing carbon sequestration capacity, as well as for improving our resilience to climate change. Therefore, it is primordial to adequately integrate biodiversity aspects in policies and measures in the context of the transition towards climate neutrality.

In order to fully benefit from the synergies between climate mitigation and adaptation and biodiversity protection, an assessment should be undertaken to identify effective policy measures in this regard, such as nature-based solutions, actions to restore ecosystems and options related to agriculture and sustainable diets and consumptions patterns. The analysis on the impacts of our imports of biomass and bio-based products (in the framework of the strategy for a bio-economy), should include the biodiversity impacts of such imports, to better understand the indirect effects and thus make better informed policy decisions.

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characteristics. This is important to avoid double counting of the sink, as climate models, calculating remaining global carbon budgets, already take into account the existence of natural carbon sinks. It is essential to further clarify the share of the accounted natural carbon sink we can use to compensate for residual emissions, without double counting the carbon sink.

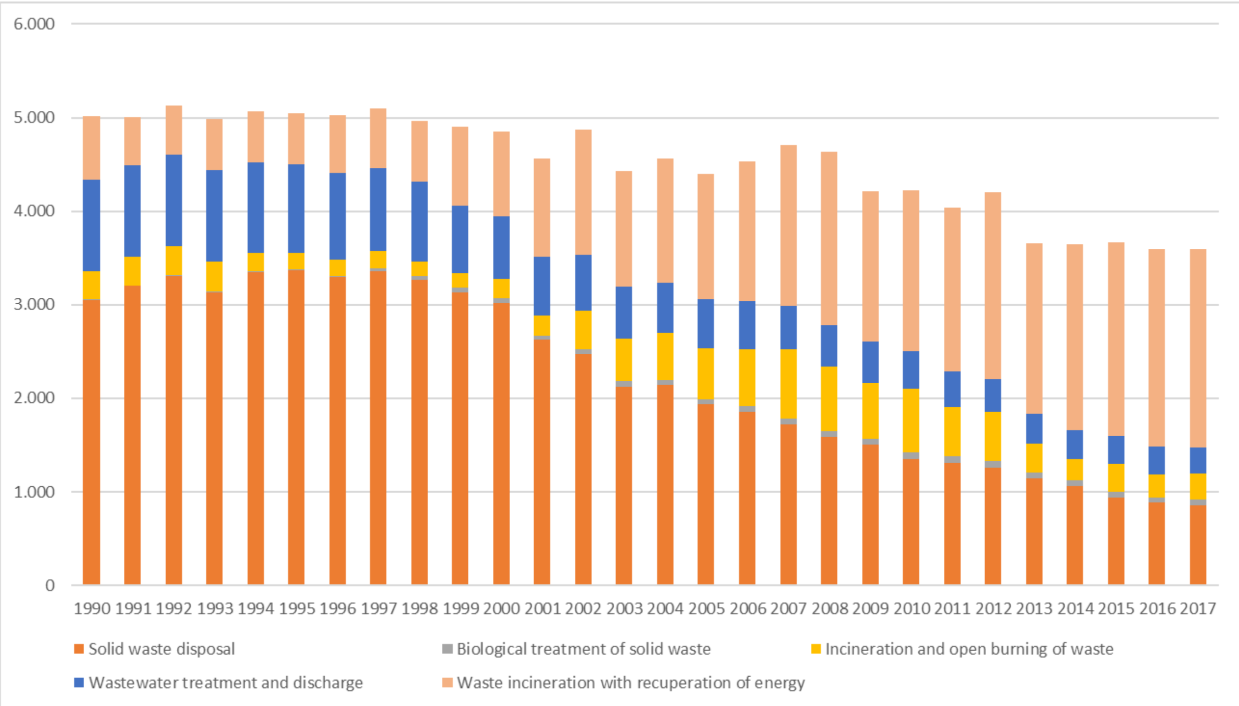
[24] Cf. reference under workstream I.5.

3.6 Waste

3.6.1 Where we are

In 2017, the emissions from the waste sector (including waste incineration with energy recuperation) represented 3,14% of total Belgian greenhouse gas emissions. As can be seen in Figure 14, 59% of 2017 emissions from the sector stem from waste incineration with recuperation of energy, while the remaining emissions originate from landfilling of solid waste (24%), waste water treatment and discharge (7,9%), waste incineration (7,6%) and biological treatment of solid waste (1,7%).

Figure 14 : GHG emissions in the waste sector between 1990 and 2017
(in ktCO_2e)



Source: NIR 2019

The main drivers of the evolution of GHG emissions in the waste sector in the period 1990-2017 are (i) the reduced methane emissions from solid waste disposal in landfills that are the result of increased recycling, composting and incineration, and (ii) the flaring or use of the biogas from landfills.

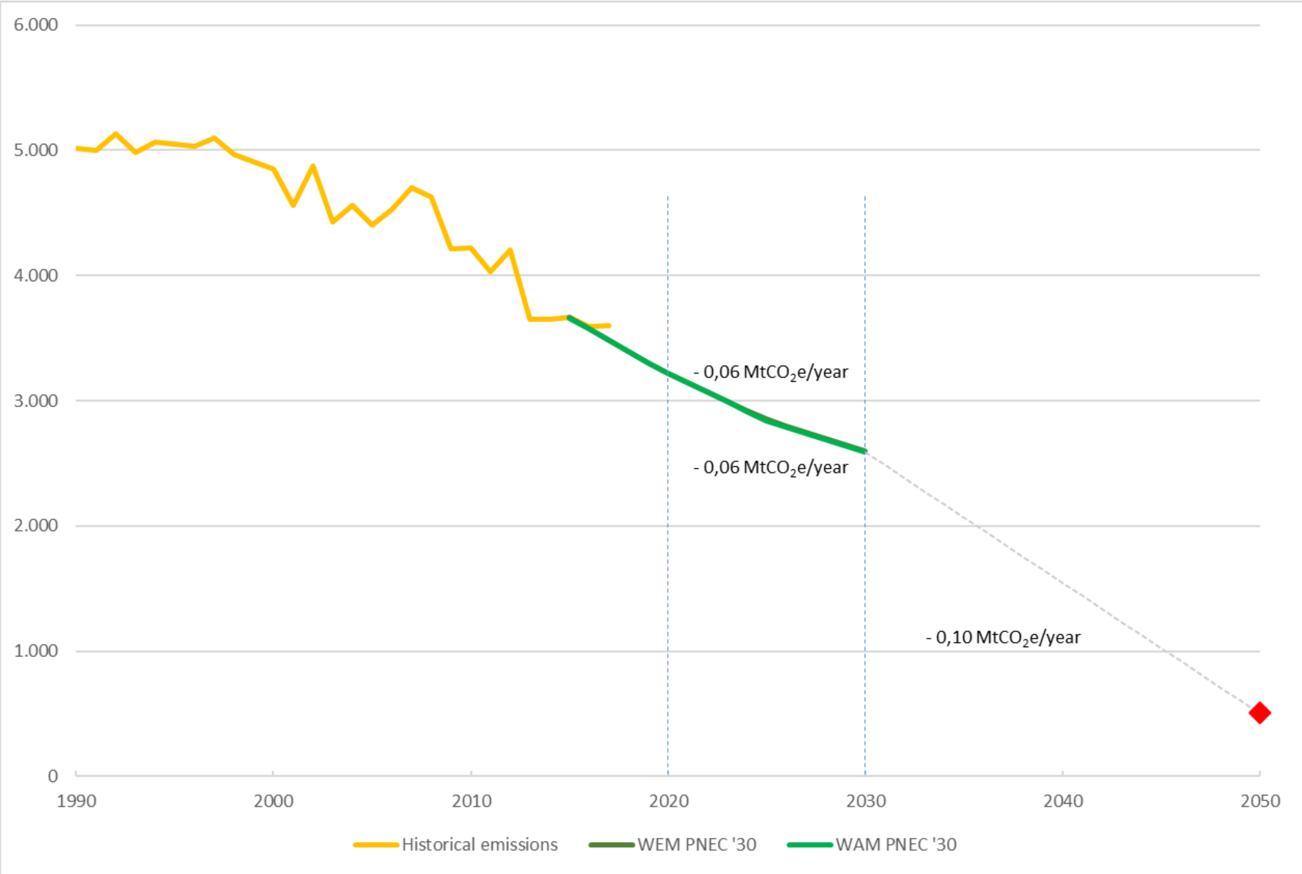
When we look at projected levels of emissions with current policies by 2030 in the context of the National Energy and Climate Plan, emissions are set to reach a reduction of 48% compared to 1990. With the additional policies and measures adopted in the Plan, emissions in the waste sector would reach a similar reduction (48%) compared to 1990.

3.6.2. Vision and levers

By 2050, CO_2 emissions from waste could be reduced to zero, while non-CO_2 GHG emissions from waste could be significantly reduced, by exploiting the complete mitigation potential. As an indicative orientation, total waste-related GHG emissions could be reduced by at least 90% with respect to 1990 (i.e. 86% with respect to 2017).

Effective and full implementation of EU waste legislation decreases GHG emissions. Additionally, limiting and eventually landfilling, reduces emissions even further. Lifestyle changes with respect to food waste, resource efficiency and the transition to a circular economy limit the production of waste in the economy. Remaining waste is as much as possible used for energy recovery. Waste water management is also improved as much as possible in order to limit methane and nitrous oxide emissions.

Figure 15 : Historical emissions and projections[25] in the waste sector, in relation to an emissions level corresponding with almost full decarbonisation and very large reductions of non-CO_2 emissions by 2050 (in ktCO_2e)



Sources: NIR 2019, NCEP, own calculations

[25] Own assumptions were made regarding the projected evolution of public electricity and heat production through waste incineration, given that this level of detail cannot be found in the publicly available projections. These assumptions might need to be reviewed in the future.

4. Transversal issues and enabling conditions

4.1 Investment requirements[26]

Previous studies have shown that the transition requires a significant increase in the level of investment in most sectors[27]. In the building sector, it is mainly the renovation of homes that will require major investments in insulation and new heating systems. In transport, large investments are needed in public transport and public infrastructure while, at the same time, the number of personal vehicles is greatly reduced. In industry, different types of investments are gradually required, including in different types of infrastructure. In energy production, additional investments relate not only to the development of renewable energies, but also to the development of the various networks. Finally, investments are required to gradually modify agricultural and forestry practices.

Most of these investments lead to considerable energy savings, the magnitude of which is often of the level of the required investments. Ongoing modelling research on transition scenarios in Belgium[28] aims, i.a., at updating and extending the quantification of these investments and the related energy savings in the different sectors.

4.2 Research, development and innovation[29]

New technologies, systems and social innovations will play an essential role to enable the transition towards climate neutrality. A clear vision towards climate neutrality and a well-aligned and focused RDI approach could yield important benefits, such as providing Belgian industries and enterprises with a leadership position in upcoming global markets.

In the different sectors a wide range of possible technologies and areas for actions are apparent. For example, in the power sector, the development of renewable energy technologies, as well as solutions to integrate increasingly higher shares of intermittent energy in the grid, will be primordial. The electrification of various sectors entails specific challenges and opportunities, while also increasing the importance of competitive electricity prices. Besides electricity, various demand side sectors will require other zero carbon energy carriers, which currently only represent a marginal share in the energy mix, such as hydrogen, synthetic fuels and biofuels. In particular regarding hydrogen, Belgium could use its frontrunner position and available knowledge to take in a leadership position.

With respect to material use and industrial production, the transition towards a more circular economy will be essential. Also, break-through technologies in different industrial sectors, in particular those with significant process emissions, should be further pursued, taking into account the global context these industries operate in.

As regards the agricultural and land use sector, more research on sustainable forestry and agricultural practices is needed, in particular in the context of the developing a bio-economy and facilitating dietary changes and more sustainable consumption patterns.

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[26] Cf. sections 3.1 and 4 of Annex IV, EU governance regulation.

[27] See for instance Climact and Vito (2013), « Scenarios for a low carbon Belgium by 2050 », as well as Trinomics, (2016), “Landscape of climate finance in Belgium”, both available at www.climatechange.be/2050.

[28] Forthcoming, see www.climatechange.be/2050.

[29] Cf. section 3.2 of Annex IV, EU governance regulation.

In general, innovation should not only focus on technology, but also take into account the social, non-technological dimension. As various new technologies will become part of our daily lives, it is important to fully grasp the benefits and potential efficiency and welfare gains these technologies can provide, whilst also ensuring that consumers and citizens have the ability and knowledge to optimally react to policy and price signals, to ensure the most cost-effective options materialise.

It is important to make sure that funding at the European level, as well as at national and regional level, are well-aligned and mutually reinforcing. In order to stimulate the roll-out or the deployment of innovative clean technologies, research and innovation should be supported along the whole value chain and strengthened cooperation among European Member States is crucial to accelerate this roll-out. Within Belgium, the Energy Transition Fund already provides an interesting blueprint of what solution-oriented research funding could look like and forms an interesting building block for devising a comprehensive research agenda.

4.3 Adaptation[30]

Belgium has adopted a national adaptation strategy in 2010 and each entity has adopted its own adaptation action plan defining priority actions[31]. A national adaptation Plan (2017-2020) aiming to strengthen cooperation and develop synergies between the different entities was adopted in April 2017 by the National Climate Commission.

A new national plan post-2020 with a time horizon of 2030 taking into account a longer-term vision will be prepared and implemented, based on the mid-term and final (2020) evaluation of the current Plan. It will address key priority sectors that need to be tackled at national level such as energy or health.

4.4 Strategic workstreams

O.1) Governance framework

As shown in the previous sections, the transition to a climate neutral society requires to deeply rethink buildings, transport, industry, energy production, land use and food systems. Societal changes of this magnitude can only be achieved through **coherent and ambitious long-term oriented policies supported by civil society and citizens**. The development and implementation of such policies necessitates an appropriate governance framework. Several analyzes and positions emanating from academics (Happaerts 2015[32]; Université de Saint-Louis, 2018[33]; Fransolet 2019[34]), advisory bodies (CFDD, 2019[35];

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[30] Cf. section 2.1.3 of Annex IV, EU governance regulation.

[31] Cf. Brussels integrated Air-Climate-Energy plan (2016); Flemish Adaptation Plan 2013-2020 (2013), Wallonia's Air-Climate-Energy plan (PACE) 2016-2022 (2016).

[32] Happaerts, Sander. 2015. Climate governance in federal Belgium: modest subnational policies in a complex multi-level setting. Journal of Integrative Environmental Sciences, 12, 4, pp. 285-301.

[33] Université de Saint-Louis. 2018. Gouvernance belge en matière de climat: Cycle de séminaires académiques: Rapport de synthèse. 25p.

[34] Fransolet, Aurore. 2019. Knowing and Governing Super-Wicked Problems: A Social Analysis of Low-Carbon Scenarios. 365p.

[35] CFDD 2019. Avis relatif à la proposition de loi « spéciale climat.

CFDD, 2016[36]; CFDD, CESRBC, CERBC, Minaraad, SERV, CESW, & CWEDD, 2014[37]; CFDD, 2013[38]) and various political and administrative actors, however, show that the current Belgian climate governance system faces a number of challenges and limits in that regard. These are largely, but not exclusively, related to the Belgian institutional framework and to its functioning when it comes to initiating transversal actions involving different levels of power and taking a medium or long term perspective. Against that background, it is essential to rethink and reshape the governance framework so that it can respond effectively to climate policy issues. A dialogue on climate governance in Belgium in 2018 led by Saint-Louis – Bruxelles University in collaboration with other members of the scientific community, has contributed to the identification of several avenues to strengthen and optimize the governance framework. Largely based on the conclusion of this dialogue, **three main axes should be further developed** in order to improve the Belgian governance framework.

A first axis concerns the **alignment of internal governance structures with the mechanisms put in place at European** (Governance of the Energy Union and Climate action) **and international** (Paris rulebook) **levels**. In this sense, a multi-level climate and energy dialogue should be established. On the programmatic level, Belgium should equip itself with more dynamic decision-making capacities in order to be able to update its integrated National Energy and Climate Plans (NECP) according to the monitoring cycles prescribed by the European Union. Second, aside from the European requirements, it is essential to **reinforce the inter-federal cooperation** on climate policy. With that aim in mind, the development of structures and mechanisms allowing a better coordination between the policies implemented by the federal and regional entities should be promoted[39]. Finally, with a view to ensuring a just transition and fostering social acceptability of climate mitigation policies, it is necessary to **recognize the pluralist needs, values, interests, issues and solutions in the decision- and policy-making process**. In this sense, it is essential to improve the dialogue between public authorities and civil society on climate change issues and to increase the involvement of the parliaments as demanded by the different members of the 'interparliamentary commission on climate' in its resolution[40]. It is equally important to broaden and deepen citizen participation by providing transparent information and permanent education on climate change issues, but also by experimenting innovative participative approaches[41].

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[36] CFDD. 2016. Avis sur la gouvernance concernant la politique climatique. 5p.

[37] CFDD, CESRBC, CERBC, Minaraad, SERV, CESW, & CWEDD. 2014. Avis sur la concrétisation de la transition de la Belgique vers une société bas carbone en 2050. 7p.

[38] CFDD. 2013. Avis sur la gouvernance en matière de politique climatique nationale et la réforme de la Commission nationale Climat. 6p.

[39] The following non-exhaustive set of proposals is given as an example: The principle of mutuality could be systematically applied in order to optimize the complementarity and synergies between the measures implemented at federal and regional levels. The functioning of existing coordination bodies such as the National Climate Commission and CONCERE could also be assessed in order to define if and how these structures can play an effective role as drivers of cooperation in the future. The inter-federal dialogue could be further strengthened by sustaining the interparliamentary dialogue on climate change initiated under the previous legislature and by introducing a 'climate day' in all the parliamentary assemblies of Belgium. In addition, the creation on an Inter-federal Climate Agency, an Inter-Ministerial Conference with tasks and responsibilities better defined than they are at present, and a national independent expert committee could be promoted. The conditions for adopting a special climate law, setting a common framework for climate action in Belgium, including long-term goals, could also be investigated.

[40] Chambre de Représentants de Belgique. 25 octobre 2018. Résolution sur la politique climatique de la Belgique en préparation de la COP.24.

[41] Like "roundtables" as in the Netherlands or parliaments composed of citizens chosen by lots for instance.

O.2) Green finance strategy

The transition towards climate neutrality will necessitate an increased level of investment. In optimal circumstances, financial flows will be directed towards the most profitable investments, while risks are adequately taken into account. A stable policy framework, based on credible and ambitious short- and long-term GHG emission targets sets out a clear direction and provides clarity for investors, companies and citizens, so they can align their investments and expenditures with our climate objectives. The clearer the outlook on the future of our economy and the expected infrastructural developments in the different sectors (transport, energy, …), the easier it is for investors to align their portfolios with the transition towards climate neutrality. By internalizing the external climate costs, for example via carbon pricing, market prices are corrected, which renders climate-friendly technologies and investments more profitable.

However, policy intervention should not only focus on the demand side of financing, as various market barriers and information problems also persist at the supply side. In order to avoid inefficiencies, unnecessarily high financing costs and investments in stranded assets, it is essential to devise a policy framework that helps the financial sector to fully take into account the transition towards climate neutrality and the existence of climate risks in their decision-making processes. A Belgian green finance strategy should be developed to support the financial sector to play its role in aligning financial flows with our climate objectives and the transition towards climate neutrality and to ensure that climate risks are taken into account in decision-making by financial actors.

O.3) Just transition

It is essential to ensure that the transition is socially fair and that no one is left behind. Macro-economic analysis shows that the investments required for decarbonizing our societies can create additional jobs and stimulate economic activity. Also, the transition will entail opportunities for innovation and new business models. However, we need to ensure that everyone can profit from the positive effects of the transition, while we need to be aware that negative consequences might be very unevenly distributed and disproportionally impact certain groups. It is essential to take the aspect of just transition into account into all policies and measures and to develop a coherent vision, integrating the climate transition into labour market policies, educational programmes, etc, in order to anticipate the impacts of the transition and develop policies and measures to deal with these impacts. In this regard, work streams B2, B3, P4 and A1 also relate to the need for a just transition and the active involvement of all citizens.

O.4) Negative emissions

By 2050, there will still be residual emissions in certain sectors, in particular agriculture and industry, mostly stemming from processes emitting non-CO2 greenhouse gases. To reach climate neutrality, these residual emissions will be compensated for by negative emissions. As the potential for negative emissions might be limited, and certain technologies might prove risky and costly, our priority is to limit the need for offsets as much as possible, in particular by fully exploiting the potential of dietary changes and the circular economy. We should also take into account that various pathways developed by the IPCC point to the fact that net negative emissions might be needed eventually in order to respect the temperature objectives from the Paris Agreement.

Firstly, natural carbon sinks can play a role to compensate residual emission (see A2). Also, carbon removal technologies might be necessary. Examples of these technologies are biomass with carbon capture and storage (BECCS) and Direct Air Capture (DAC) coupled with permanent storage. Moreover, the captured CO2 can also be used to produce materials, instead of being stored underground. If we can guarantee that CO2 stored in these materials is not emitted at the end of the lifetime, this also constitutes a permanent sink of emissions. However, it is important to develop a strong and coherent policy framework for these applications, in order to guarantee their sustainability.

A strategy for negative emissions should further clarify the opportunities and challenges the different options for negative emissions entail and set out a plan for action in this regard.

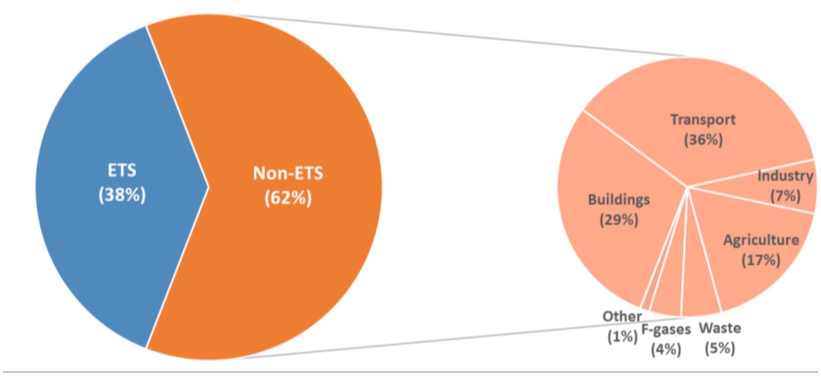
O.5) In-depth risks and vulnerability assessment of climate change in Belgium

A comprehensive overview of current and future climate change risks as well as further stress factors to be expected is required. An in-depth risks and vulnerability assessment should be conducted for Belgium taking into account the latest available climate scenarios. It should also help identify opportunities arising from climate change, and provide information on how to assess adaptive capacity and cope with uncertainty.

Systematic mainstreaming of adaptation should be ensured in decision making and planning processes at all levels (national, federal, regional)on the basis of the risks and vulnerability assessment. In parallel, the federal level and the three Regions should continue to update, strengthen and implement their adaptation frameworks in order to ensure the resilience of key vulnerable sectors.

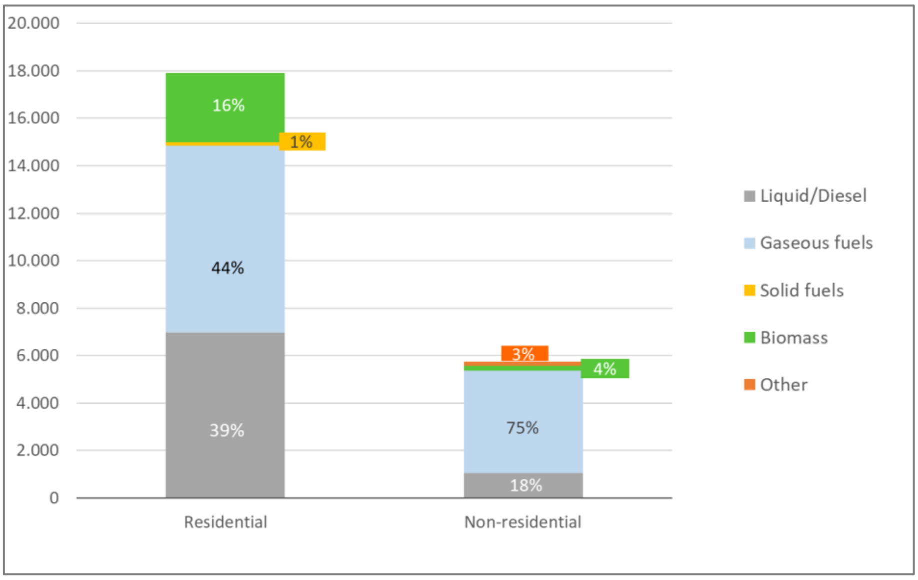
Appendix 1: Additional figures

Figure A1 : 2017 share of ETS and Non-ETS emissions in Belgium, and Non-ETS emissions per sector (in %)



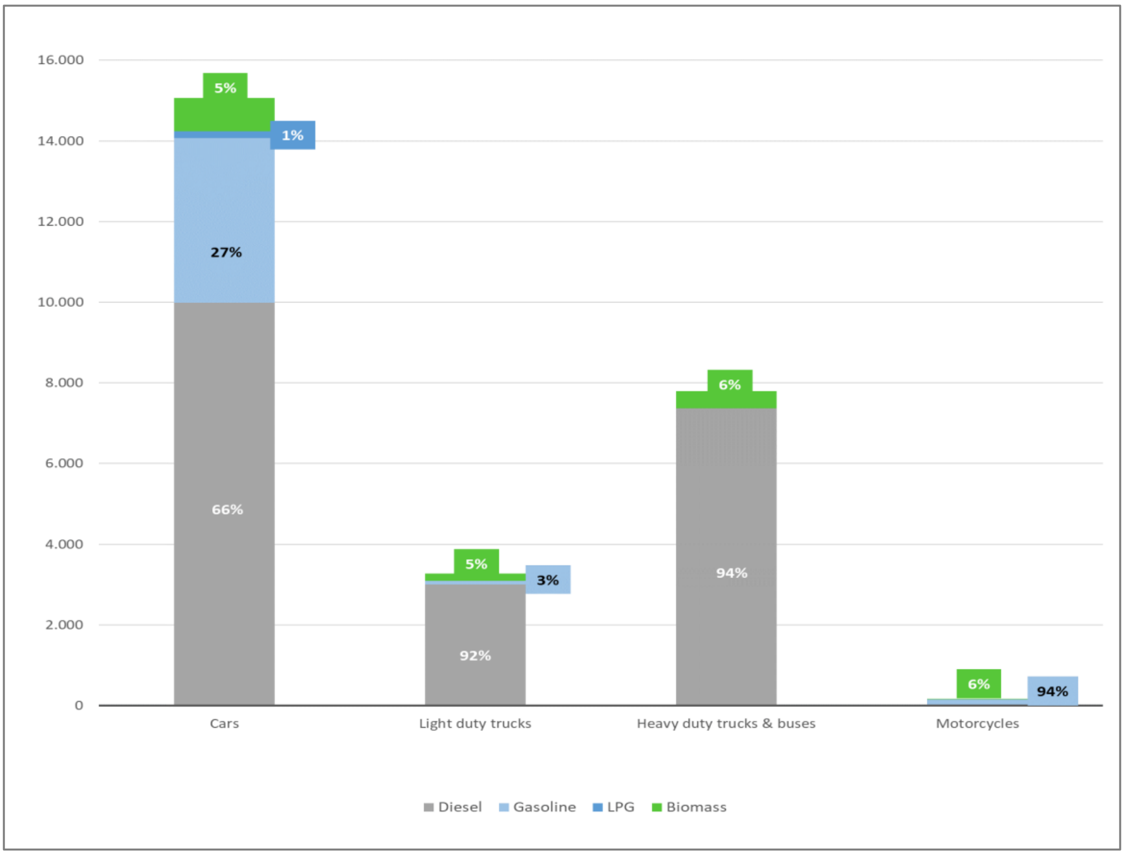
Source: NIR 2019

Figure A2 : 2017 GHG emissions in the buildings sector by fuel type (in ktCO2e)



Source: NIR 2019

Figure A.3 : 2017 CO2 emissions in road transport per energy source
(in ktCO2 and in percentage per category)



Source: NIR 2019

Figure A4 : 2017 share of Belgian industry emissions in total emissions, and origin of industry emissions