Projections of greenhouse gas emissions by sources and removal by sinks:

Information on the assumptions, parameters, methods and model description

Reporting under Article 18 of Regulation (EU) 2018/1999

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1 Projections

1.1 Introduction

The greenhouse gas emission projections were elaborated in the course of 2022 based on the most recent information available on the macro-economic context and policy implementation. As these projections were developed in 2022, they could not yet take into account the expected impact of the energy crisis. For the reference year 2019, unadjusted emission data from the inventory submission in 2023 (dated 15/03/2023) taking into account the 2006 IPCC Guidelines for National Greenhouse Gas Inventories are presented in this report and the reporting templates. As part of an update and resubmission in September 2023, projections for the period 2030-2050 have been added. Projection scenarios are not yet available for the Flemish region for the period 2035-2045. For these years, the WEM and WAM scenarios were set equal to 2030. For 2050, the WAM projection scenario was aligned with the Flemish Climate Strategy 2050.

Except for electricity production, the reported projections are the sum of the bottom-up projections of the three regions (Flanders, Wallonia, Brussels-Capital) which are calibrated on the regional energy balances. The bottom-up approach starts from the demand side of the different sectors (industry, domestic, tertiary, transport, …) and results in sectoral energy projections. Within this approach, relations between energy consumption, activity levels and energy prices are assessed at a sectoral level. The electricity production and the bunker fuel emissions are modelled at national level.

1.2 General projection Assumptions

The following general assumptions are used in the calculations of regional bottom-up emission projections (unless otherwise indicated).

All implemented and adopted (EU, federal, regional) policies and measures, considered until the end of 2022, have been taken into account in the 'with existing measures' (WEM) scenario. Planned policies and measures or targets have been integrated in a scenario with additional measures (WAM).

The section below summarises the general assumptions included in the WEM and WAM scenario.

1.2.1 Emission factors

Emission factors reported in the 'Belgium's Greenhouse Gas Inventory (1990-2020) National Inventory Report'[1] have been used for the calculation of the projections.

More specifically, the emission factors for the energy related CO_2 projections (CRF Cat 1A Fuel Combustion Activities) are presented in Table 1.1. The emission factors for coke, petroleum coke, coke oven gas, refinery gas and blast furnace gas are adjusted values based on inquiries with the sector, in contrary to the other factors which are IPCC default values. In the Brussels-Capital Region, waste emission factors are estimated based on measurements in the incinerator.

[1] https://unfccc.int/sites/default/files/resource/bel-2022-nir-23may22.zip

Fuel	Emission factor (kton CO_2/PJ)		
	Flanders	**Wallonia**	**Brussels**
Hard coal	94,6	98,3	94,6
Cokes	107,0	104,5	
Brown coal, lignite		101,2	
Other solids (waste, ...)	variable	variable	Variable
Natural gas	56,4	56,1	56,1 56,5[2]
Cokes oven gas	38,0-40,0		
Blast furnace gas	250,0- 265,0		
Refinery gas	55,1 - 56,5		
Heavy fuel oil	77,4	77,4	77,4
Petroleum cokes	97,5	97,5	
Light fuel oil, gas oil	74,1	74,1	74,1
Gasoline	70,0	69,3	
LPG	63,1	63,1	63,1
Other petroleum products	73,3	73,3	

Table 1.1: Emission factors used for the energy related CO_2 emission projections.

1.2.2 Global Warming Potential

CO_2 equivalent emissions and projected emissions 2016-2050 are calculated using the Global Warming Potential (GWP) values specified in the UNFCCC reporting guidelines on annual inventories according the fifth assessment report of IPCC - AR5 (Table 1.2).

Greenhouse Gas	GWP
CO_2	1
CH_4	28
N_2O	265

Table 1.2 : Global warming potentials.

1.2.3 Climate assumptions

The regional and national projections for the residential and tertiary sector are calculated assuming that the number of degree-days for the period 2020-2050 is equivalent to the average degree-days of the 2012-2021 period. This average is equal to 1.761 degree-days (reference 15/15) and characterised a mild climate.

[2] Only for CRF sector 1A4.

1.2.4 Demographic evolution

The demographic projections presented in Table 1.3 are based on the prospects by the Federal Planning Bureau[3]. They were calculated per age, gender and district.

	Statistics	Prospects					
	2019	2025	2030	2035	2040	2045	2050
Population Belgium	11.431.406	11.734.514	11.938.695	12.154.523	12.336.219	12.494.430	12.621.225
Number of households Belgium	4.948.398	5.113.517	5.259.840	5.449.795	5.560.935	5.642.731	5.703.555
Average household size Belgium	2,31	2,29	2,27	2,23	2,22	2,21	2,21

Table 1.3 : Demographic evolution.

1.3 Projections by sector

1.3.1 CCUS

Flanders

The Flemish region holds the largest integrated fuel and chemical cluster in Europe and is hence responsible for important emissions of concentrated CO_2 on a relatively limited surface. In general, these are the result of ehtylene and hydrogen production or other chemical processes, the refining of mineral oil, steelmaking, waste incineration and natural gas plants in the elecitricity sector, which are all or might be covered by the EU Emissions Trading Scheme.

The Flemish region is hence a suitable location to establish new collaborations and innovative integrated systems that allow the capture of up to tens of millions of tons of CO_2 per year, their compression, cleaning and liquification if needed, and their tranport either via pipelines or ship with the aim of their permanent geological storage and/or their usage back into useful products (such as recycled carbon fuels).

As also mentioned in paragraph 7.1.5.2. of the updated Flemish Energy and Climate plan 2021-2030, the Flemish region is – amongst other initiatives both at the Flemish and European level – currently creating the necessary legal framework to allow for large-scale projects in the Flemish region to be implemented by 2026 and beyond. One of the very important projects is the Kairos@C project in the Antwerp port.

Whereas this comes with several uncertainties, it is not unrealistic that the amounts of CO_2 that will be captured will be as mentioned in Table 1.4.

Whether and how much of these amounts of CO_2 will be transported for permanent geological storage and/or used back into useful products, is difficult to predict. It is therefore also difficult to predict whether these amounts will all result in net CO_2 reductions in the Flemish (and Belgian) greenhouse gas inventory, as this will also depend (in the case of CCU) on where and in which sectors recycled carbon fuels will be consumed.

[3] https://www.plan.be/databases/data-35-fr-perspectives_de_population_2021_2070

2030	2050	Sector
3,0	3,0	Chemical (CRF category 2)
2,0	2,0	Iron and steel (CRF category 2)
-	3,0	Electricity production (CRF category 1)
-	1,0	Waste incineration (CRF category 1)
-	2,0	Refineries (CRF category 1)
5,0	11,0	Total

Table 1.4. CCUS projections in Flanders (Mton CO_2)

1.3.2 The power sector (electricity production) (CRF category 1A1a and autoproducers in other CRF categories)

Projections for 2030[4] in the power sector are modelled at national level by the Federal Planning Bureau with the Crystal Super Grid model of the company Artelys. The model is a "unit commitment optimal dispatch" model. "Unit commitment" refers to the process that determines which units are activated at which time and are then able to produce electricity. As for the 'economic dispatch', it relates to the actual production of the various plants successively activated according to the cost-efficiency criterion.

The model inputs used are:

- European power sector data (e.g., capacities, availabilities, power demand,…) from TYNDP 2020 study developed by ENTSOE[5]. The scenario used is the "National Trends" which is based on the objectives of the PNEC 2019.
- Updated yearly projected electricity generation according to the Belgian entities (i.e., RES, CHP, Nuclear, Waste, Derived Gases) as reported in Table 3 (projections reporting template). Production curves come from climate database from ENTSOE.
- Updated yearly projected electricity demand according to the Belgian entities Table 3 (projections reporting template). Unitary hourly load curves come from climate database from ENTSOE.

The model outputs used in the projections are:

- Electricity generation from gas and oil power plants.
- Imports and exports of electricity.

[4] Projections in 2025 consists of interpolation between base year 2019 and projected year 2030

[5] https://2020.entsos-tyndp-scenarios.eu/#download

	Statistics	WEM						WAM					
	2019	2025	2030	2035	2040	2045	2050	2025	2030	2035	2040	2045	2050
Final consumption, distribution losses and (own) use energy sector	91,4	87,8	94,6	90,5	90,7	91,8	93,1	89,2	99,4	96,5	97,5	100,1	137,2
Net import (balance export – import)	-1,9	16,7	17,7	7,5	16,1	14,8	13,9	9,7	14,0	4,3	5,1	5,7	17,7
Gross production	93,2	71,2	76,9	83,0	74,6	76,9	79,1	79,5	85,4	92,2	92,4	94,4	119,5

Table 1.5: Electricity demand and supply for Belgium (TWh)

The results in Table 1.5 show an increase of the electricity consumption between 2019 and 2030 with 6% in the WEM scenario and with 13% in the WAM scenario (i.e. respectively 0,6% and 1,2% per year on average).

The trans-boundary electricity trading in 2030 is endogenous and modelled across all EU countries. The evolution of net imports in Belgium depends thus on the interconnection capacities, power demand and power generation fleet of each EU country. Net imports in 2025 are not modelled and are estimated to meet power demand in 2025.

The WEM and WAM scenarios integrate the phase-out of nuclear energy in Belgium. On 31st January 2003, the Federal Government decided the progressive phase-out of the production of electricity using nuclear fission energy by limiting the operating lives of existing nuclear power plants to 40 years and prohibited the construction of new nuclear power plants. In July 2012, the Federal Government confirmed this timetable except for one nuclear unit, Tihange 1, whose operation lifetime was extended by 10 more years. This decision was confirmed in a law (18th December 2013). On 18th June 2015, another extension was approved (for the Doel 1 and Doel 2 units) through an amendment of the law of 31st January 2003. In March 2022, the Federal Government decided to extend Doel 4 and Tihange 3 for 10 additional years. WEM and WAM scenarios consider this 10 years extension.

The timetable for the nuclear power phase-out between 2022 and 2035 mentioned in Table 1-6 has been taken into account in the WEM and WAM scenarios.

Nuclear unit	Capacity (MW)	Closing date WEM	Closing date WAM
Doel 1	433	15th February 2025	15th February 2025
Doel 2	433	1st December 2025	1st December 2025
Doel 3	1.006	1st October 2022	1st October 2022
Doel 4	1.039	1st July 2025 / 1st December 2036[6]	1st January 2036[7]
Tihange 1	962	1st October 2025	1st October 2025
Tihange 2	1.008	1st February 2023	1st February 2023
Tihange 3	1.046	1st September 2025 / 1st December 2036[6]	1st January 2036[7]

Table 1-6: Nuclear phase out

An increase in the offshore wind capacity after 2020 has been assumed in the WEM and WAM scenario (Table 1-7).

	2019	2025	2030	2035	2040	2045	2050
WAM scenario	1.555,5	2.261,8	5.761,8	5.761,8	8,000.0	8,000.0	8,000.0
WEM scenario	1.555,5	2.261,8	5.411,8	5.411,8	5.411,8	5.411,8	5.411,8

Table 1-7 : Offshore wind capacity WEM and WAM scenario (MW)

The calculation of the CH_4 and N_2O emissions of the electricity production sector is performed applying the CH_4 and N_2O emission factors on the final energy carriers. Wood and other biomass burning is only taken into account for the projections of CH_4 emissions.

For the CO_2 emission projections originating from waste incineration each region applies its own methodology as specified in the National Inventory Report. The CO_2 emissions from waste incineration with energy recuperation are reported in the energy sector as 'other fuels' for the non-organic part and as 'biomass' for the organic part. The emissions from 1 industrial waste incinerator in the Flemish region (auto-generator) are allocated to CRF category 1A4a. CO_2 emissions originating from flaring activities in the chemical industry are allocated to the waste sector (CRF category 5C).

Flanders

The WEM and WAM projections with regard to electricity production from renewable sources, as mentioned in the draft update of the Flemish Energy and Climate Plan 2021-2030[8], haven been taken into account.

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[6] Exact date not yet known.

[7] Exact date not yet known.

[8] https://www.vlaanderen.be/veka/energie-en-klimaatbeleid/vlaams-energie-en-klimaatplan-vekp-2021-2030

		WEM		WAM	
	2019	2025	2030	2025	2030
Solar	3,0	5,2	6,1	5,9	8,2
Wind onshore	2,8	4,2	4,5	4,3	5,7
Hydro	0,01	0,01	0,01	0,01	0,01
Biomass	2,4	1,6	1,3	1,6	1,3
Biogas	0,7	0,8	0,8	0,8	0,8
Total	8,9	11,8	12,8	12,6	16,0

Table 1.8 : Renewable electricity Flanders in WEM and WAM scenario (TWh)

Wallonia

The impact of support for green electricity production (“green certificate”) is taken into account for the WEM scenario. Several measures (financing mechansims, removal of administrative ans legal obstacles, …) increase electricity renewable energy targets in the WAM scenario around 14 TWh in 2030, in accordance with targets of the Air Climate Energy Plan for 2030.

Waste incineration remains stable in WEM and WAM scénario.

In the case of gas combined heat and power production system (CHP), the estimation considers “envelopes” from green certificate and after, technology choice is based on the result of the optimisation after the definition of a realistic potential of deployment.

Brussels-Capital Region

WEM SCENARIO

Regarding electricity and heat production, the estimations are based on historic evolution of the waste incinerator according to the regional energy balance; this is also the case for the waste water handling installations. In the case of the CHP), the estimation considers the average operating hours and the average annual evolution of the installed power between 2011 and 2021. The WEM scenario considers that biomass CHP will phase out on 2025. “Green certificates” will not be granted after 2030 meaning the end of the CHP production at the year 2040.

Concerning heat pumps, solar and photovoltaic panels’ production projections, the WEM scenario assumes that the projected evolution follows the historic trend from energy balances. Finally, the scenario considers that the turbojet will work until 2038.

WAM SCENARIO

Comparing to the WEM scenario, the WAM scenario considers a reduction of 30% of incinerated waste in 2030. Part of the organic waste will go to a small anaerobic digestion plant starting in 2026. Regarding Gas CHP, the WAM scenario assumes that the “green Certificates” will come to an end in 2025 thus CHP installations will be out in 2035. For photovoltaic panels, the WAM scenario includes the additional production of 5GWh installed in social housing and an annual growth of 8% until 2030

1.3.3 The (energy) conversion sector

1.3.3.1 Refineries (CRF categories 1A1a, 1A1b, 1B2c, 1B2a4)

Flanders

Refining is an activity that only takes place in the Flemish region. The WEM and WAM emission projections assume that the capacity of the refineries in Belgium will not increase after 2019. As described in the Belgian National Inventory Report CO_2 emissions of the refineries are allocated to the sectors:

- 1A1a for the involved combined heat-power installations of the refineries;
- 1B2c for the flaring emissions;
- 1A1b for the total emissions excluding the emissions of the combined heat-power installations and excluding the emissions from flaring activities.

The N_2O and CH_4 emission projections from refining activities are estimated by applying emission factors to the final energy carriers. The CH_4 emissions have a diffuse character and include the flaring emission projections of the refineries for the Flemish region.

All CH_4 emissions of this sector (except the emissions of the combined heat-power installations which are allocated to the sector 1A1a) are allocated in category 1B2a4 and all N_2O-emissions (except the emissions of the combined heat-power installations which are allocated to the sector 1A1a) are allocated in category 1A1b. The emissions of CH_4 reported in the category 1B2a4 also contain the flaring activities of refineries.

1.3.3.2 Coke production (CRF category 1A1c)

Flanders

In Flanders the WAM and WAM scenario assumes one coke production plant in steel industry operating at maximum capacity in the period 2019-2050 and equipped with a desulphurisation unit.

Wallonia

In Wallonia, the last coke factory was closed in 2014 and it is not expected that a new plant will be built.

1.3.3.3 Oil transport (CRF category 1B2a3)

Flanders

Fugitive emissions of CO_2 and CH_4 from oil transport are assumed to remain constant at the 2019 level.

1.3.3.4 Gas transmission and distribution (CRF category 1B2b)

Flanders

Projections of fugitive CH_4 emissions from the distribution of natural gas in Flanders are calculated based on assumptions on the evolution of the natural gas network and the gradual replacement of pig iron pipes by PE, PVC or steel. The expansion of the natural gas network in Flanders is estimated taking into account the increase of the number of households and the number of houses in residential areas with the possibility to connect to the natural gas distribution grid.

Wallonia

Calculation of CH_4 emissions from the distribution of natural gas in Wallonia is based on the assumption that the network expands lightly each year. The emissions are supposed to stay constant as pig iron pipes and asbestos cement pipes will continue to be replaced, all new distribution pipes being made of steel or PE/PVC.

Brussels-Capital Region

Fugitive emissions considered in Brussels-Capital Region are due to the distribution of natural gas; the emissions remain constant since the network will not be extended.

1.3.4 The industrial sector

1.3.4.1 Energetic CO_2 emission in the industrial sector (CRF category 1A2)

Projections of energy use in the industry sector are based on assumptions of activities and also the energy intensity (amount of energy used per unit of activity).

Flanders

The energy consumption and CO_2 emissions in the industrial sector in the WEM have been modelled taking into account the expected energy efficiency improvement, based on current energy agreements, and activity projections. Increased energy efficiency and additional fuel shift assumptions have been considered in the WAM scenario.

The industrial off-road emissions are calculated by using the OFFREM-model with emission factors of the IPCC 2006 guidelines (CO_2 and CH_4) and EMEP/EEA guidebook (N_2O). Off-road emissions of the industrial sectors are allocated (incl. construction industry) in category 1A2gvii.

Wallonia

The evolution of economic activity is taken into account via requests for energy services specific to each industrial sub-sector[9] (either via an assumption of stability compared to 2018 or via an assumption of evolution equal to the average of the years 2014-2018). Investment projects and equipment closures that have taken place or have been announced have been considered.

All major industries are involved in 'second generation' branch agreements whereby they are committed to improve their energy/CO_2 efficiency by 2023. Technology choice is based on the result of the optimisation, challenged and brought into line with monitored voluntary agreements results for the WEM scenario.

Brussels Capital Region

WEM AND WAM SCENARIOS

The projections are calculated on the basis of energy intensity. Industry sector in Brussels Capital Region faced an important decrease from the year 2000. Between 2008 and 2021, it has stabilized, representing approximately 3% of final energy consumption in the region. The perspectives of a future expansion are very low. The projections assume that the gross added value will progress according to the middle term projections 2022-2027[10]; from 2028 until 2040 this value remains constant.

The 8th December 2016 a decree has been approved concerning energy audits obligations[11]. This decree is included in the WEM scenario. The objective is to diminish total energy consumption of the biggest

[9] The industrial sector is divided into 20 subsectors : milk, sugar, transformed potatoes, other food industry, cement, lime, hollow glass,flat glass, bricks, ceramics, other non-metallic minerals, ammonia, other chemicals, wood industry, pulp and paper, iron and steel, non-ferrous metals, non-energy consumption (chemicals and others) and other industries.

[10] https://www.plan.be/databases/database_det.php?lang=fr&ID=27

[11] Arrêté du Gouvernement de la Région de Bruxelles-Capitale relatif à l'audit énergétique des grandes entreprises et à l'audit énergétique du permis d'environnement approuvé en troisième lecture le 8 décembre 2016.

industrial companies located in the region, so companies consuming more than 28 GWh per year in primary energy must do an energy audit.

1.3.4.2 Process emissions of CO_2 (CRF category 2A, 2B, 2C)

Flanders

Main non-energetic uses of fuels in Flanders:

- natural gas for ammonia production (carbon converted to CO_2 emissions);
- natural gas for processes where the carbon is fixed in the end-products;
- natural gas for the production of hydrogen and ethylene oxide;
- naphtha and LPG in crackers and in other processes (carbon fixed in end-products);
- heavy fuel oil for production of carbon black; use of coal-tar in one company.

Because it concerns non-energetic use of fuel it is assumed that climate policy will not have an effect on the use of the fuels mentioned above. In addition, there are also several processes with chemical reactions, in which carbonaceous products, generally not considered as fuels, are oxidised to CO_2. Such process emissions occur in the chemical industry (production of ethylene oxide, acryl acid, cyclohexanon, synthetic soda), in refineries, in the sector of non-metallic minerals, and during flaring and the desulphurisation of flue gasses.

As from the inventory submission in 2015 some emission categories have been re-allocated to CRF category 2 according to the IPCC 2006 guidelines:

- The emissions from the solid fuels (cokes gas, blast furnace gas, cokes grid and anthracite) have been re-allocated from the category 1A2a in previous submissions to the category 2C1a for the only big integrated steel plant in Flanders.
- The emissions from the production of ethylene are included in category 2B8b since the inventory submission in 2015. Until the inventory submission in 2014 these emissions were allocated to the category 1A2c (other fuels). These emissions cover the recovered fuels in the steamcracking units in the petrochemical industry and other recovered fuels from the chemical industry.

The current inventory allocation method has been used for this projection report.

Projections of CO_2 process emissions are linked to activity assumptions which are mainly based on the results of the EU Reference Scenario 2020[12] for Belgium.

As mentioned in chapter CCUS1.3.1, CCUS is taken into account for process emissions in the chemical sector and the iron and steel sector.

Wallonia

Main non-energetic uses of fuels in Wallonia:

- coal in the iron and steel industry and selected applications of engineering (metallic works);
- petroleum products in several sectors, notably in the chemical industry;
- natural gas for ammonia production (carbon converted to CO_2 emissions)

Emissions from processes considered in Wallonia are the following:

- CO_2 produced by the decomposition of limestone in cement and lime productions;

[12] https://energy.ec.europa.eu/data-and-analysis/energy-modelling/eu-reference-scenario-2020_en

- CO_2 produced by the decomposition of methane to produce ammonia (and considered separately from CO_2 emitted by the actual combustion of methane)

Projections of CO_2 process emissions are linked to growth rates of activity and have therefore been kept constant in WEM scenario.

The emissions are decreasing in the WAM scneario after 2030, thanks to new technologies (hydrogen, carbon capture, ….).

1.3.4.3 CH_4 and N_2O emissions in the industrial sector (CRF category 2)

The CH_4 and N_2O emission projections for the industrial sector are made using the emission inventory methodology reported in the National Inventory Report.

CH_4 emissions in the industrial sector originate mainly from the iron and steel sector in Flanders (sinter production). The same activity growth trend as mentioned in section 1.3.4.1 above are assumed. The emission levels are directly linked with this same growth trend.

The N_2O emission originates from caprolactam (Flanders) and nitric acid (Flanders, Wallonia) production.

N_2O emission projections of caprolactam production are based on information from the concerned company regarding activity data and implementation of reduction measures. In the WEM scenario the application of an end-of-pipe technique has been considered. Additional reduction measures which still require further research have been taken into account in the WAM scenario.

N_2O emission projections of nitric acid production in Flanders is assumed to remain constant at the 2019 level. In Wallonia, N_2O emission projections of nitric acid projections are based on information from the concerned company regarding activity data and implementation of reduction measures. Reduction measures were implemented in 2011, resulting in a large decrease of N_2O emissions. The emissions have been considered the same in the WEM and the WAM scenario.

1.3.4.4 Non-energy products from fuels and solvent use (CRF category 2D)

Flanders

The emissions of non-energy products from fuels and solvent use are considered constant at the 2019 level for the entire projection period. This category includes:

- The CO_2 emissions from the use of lubricants (CRF category 2D1);
- The CO_2 emissions from the use of paraffin wax (CRF category 2D2);
- The CO_2 emissions from the urea used as a catalyst (CRF category 2D3).

Wallonia

The emissions of non-energy products from fuels and solvent have remained stable for 10 years around 35-40 kt CO_2. Those emissions are kept constant and equal to 35,16 kt CO_2 for the entire projection period for both WEM and WAM scenario.

Brussels-Capital Region

The use of non-energy products is kept constant for the entire period.

1.3.4.5 The 'Other product manufacture and use' Sector (CRF category 2G)

Only the use of N_2O as anaesthetic and aerosol cans is included in this category.

Flanders

N_2O emissions from this use in Flanders are kept constant at 2019 emission levels. Due to the lack of information about the evolution of consumption, the last historic value has been considered constant for the entire projection period.

Wallonia

N_2O emissions from this use in Wallonia are kept constant at 2018 emission levels. Due to the lack of information about the evolution of consumption, the last historic value has been considered constant for the entire projection period for both WEM and WAM scenario.

Brussels-Capital region

The use of N_2O as anaesthetic and aerosol cans is included in this category. For Brussels Capital Region, the information on anaesthetic use is based on the regional sales of anaesthetic. Due to the lack of information about the evolution of anaesthetic consumption, the last historic value has been considered constant for the entire projection period.

Emissions due to the use of aerosol cans are also estimated in the RBC inventory considering a constant consumption per inhabitant. The emission projections of aerosol cans are based on population data from the Federal Planning Bureau (see section 1.2.4).

1.3.4.6 F-gas emissions (CRF category 2)

WEM scenario

The F-gas emission projections are drawn up from the model developed by ECONOTEC Consultants and VITO in the context of a study commissioned by the Federal Department of the Environment on behalf of the National Climate Commission[13].

WAM Scenario

In **Wallonia**, the WAM scenario considers a decrease of the emissions by 2030 compared to 2005.

In the **Flemish region,** the WAM scenario takes into account additional measures that are included in the draft update of the Flemish Climate Policy Plan for the period 2021-2030 and that aims at reducing the F-gas emissions to 0,6 Mton CO_2-eq in 2030 for the Flemish Region. The following additional measures are considered:

- Strengthening of the economic support instruments, particularly the Ecologiepremie+ subsidies (possible extension beyond 2020 and to other technologies);
- Support for new or existing training centres with adequate equipment;
- Fostering of a Green Deal with the retail sector, to reduce its use of F-gases to practically nil and its emissions to a minimum in 2030.

1.3.5 The residential sector (CRF category 1A4b)

The climate regulations and measures considered for the WEM and WAM projections are presented in more detail in the PAMs reporting. The assumed evolution of the population and the number of households is discussed in section 1.2.4 above. Estimates are made on the number of new dwellings. Distinction is made between new and existing houses.

[13] https://www.cnc-nkc.be/sites/default/files/report/file/final_report_2022_public_-_projections.pdf

Flanders

Heating and equipment

- New dwellings (WEM and WAM scenario):

As of 2021 it is assumed that the heat demand of all new single-family dwellings and apartments respect an E-level of 30 following the implementation of the EC directive on energy performance of buildings.

- Existing dwellings:

  For existing dwellings, projected fuel consumption in the WEM scenario is determined by:

  - The average fuel consumption in an existing dwelling in 2019 and the evolution of the number of dwellings;
  - The impact of renewable energy policies (solar boilers and heat pumps), autonomous boiler efficiency improvements and also thermal insulation measures based on the current subsidy system.

  The main additional measures included in the WAM scenario are listed below:

  - Accelerated renewal of heating systems;
  - Prohibition on new gas connections in new residential complexes;
  - Optimization of settings of existing heating systems;
  - Demolition subsidy ;
  - Reduction in VAT for renovations.
  - Renovation obligation
  - Reform of subsidy system
  - Prohibition of new heating oil boilers

Fuel mix

The projected fuel mix of existing dwellings starts from the current distribution of energy carriers and takes into account the expected yearly fuel switch (installation switch from fuel oil to natural gas heating systems) and the number of heat pump installations. An increased number of heat pump installations has been assumed in the WAM scenario based upon the WAM-scenario for renewable energy. The fuel mix for new dwellings depends on the E-level pathway.

Equipment

It is considered that 80% of the historic electricity was used for electrical appliances and lighting. The remaining 20% of the consumption is used for electric heating and sanitary hot water preparation. The evolution of the power consumption of electrical appliances and lighting has been simulated taking into account the results of the EU Reference scenario 2020.

Off-road

The off-road emissions of the residential sector are calculated by using the OFFREM-model with emission factors of the IPCC 2006 guidelines (CO_2 and CH_4) and EMEP/EEA guidebook (N_2O). Off-road emissions of the residential sectors are allocated in category 1.A.4.b.ii (Off-road vehicles and other machinery).

Wallonia

<u>WEM scenario</u>

Space heating and hot water

For new dwellings, the heat demand takes into account the current EPB regulation in Wallonia with the following requirements from 2021 : Ew = 45; Espec = 85 kWh/m²/year (where E_w is the "primary energy consumption level" and E_{spec} is the "specific primary energy consumption level").

For existing dwellings, 20 different categories of existing buildings are taken into account. For each category, the surfaces and net needs are described. Retrofitting options (roof, wall, floor and window) are also differentiated according to the 20 categories of buildings defined above. A decrease of specific energy consumption of existing housing is calculated based on energy savings per type of renovation and a number of annual renovations coherent with the results from energy grant system.

Concerning the fuel mix, a set of technologies is described in the model through standard parameters (efficiency, lifetime, …) which can evolve (improved performance, …). Installation switch from fuel oil to natural gas heating systems[14] and share of renewable energy (mainly biomassa and heat pumps) slightly increases in the fuel mix (thanks to EPB requirements for new houses and energy grant system).

Other uses

The demand for other energy services for the residential sector including lighting, cooking, refrigeration and freezing, cloth washing and drying, dish washing, and other electricity services follows the evolution of the number of households.

For electric equipment, new technologies are described according to the best available technologies.

WAM scenario

The WAM scenario for residential sector includes different measures:

- For all buildings, more heat is produced by renewable energy (biomass, heat pumps, …), in accordance with targets of the Air Climate Energy Plan for 2030. The gradual withdrawal of oil-fired installations is medeled in accordance wih the planned regulatory measure.
- For existing buildings, the targets of the **"**Long term Renovation Strategy"[15] and its intermediate objectives are taken into account. It will reduce the environmental impact of existing buildings. This strategy defines different objectives for energy efficiency of the envelope and the equipments of the existing buildings.

This scenario wil require the implementation of new measures or the improvement/widening of some measures taking place in the WEM scenario.

Brussels-Capital Region

WEM SCENARIO

The residential emission projections consider the historic trends between 2001 and 2019 on energy consumption, household size, and population. The projections also reflect the application of the Brussels

[14] Taking into account some limits linked to gas infrastructure, barriers to system change, … Only 20% of oil installations at the end of their life are replaced by an alternative system.

[15] https://energie.wallonie.be/fr/strategie-de-renovation.html?IDC=9580

Capital Region Government's Decree[16] regarding Energy Performance of Buildings. This decree considers that all new buildings will be nearly passive (15kWh/m^2.yr) and heavy renovated buildings will consume 30kWh/m^2.yr.

The measures taken into account in the WEM scenario are related with the energy management and technical installations in buildings. The technical reception of a new boiler installation is one of these measures. In fact, when a new boiler is installed, the entire heating system must be controlled by a certified technician; this action allows 25% reduction from heating consumption. Boiler replacement rate was estimated from the data provided by the Thermal Technique Belgian Association (ATTB, French acronym) and it was deduced from the boilers replaced with energy grants.

The third measure is also related to the heating installations. The mandatory control is applied for boilers that are part of a heating system with a nominal power higher than 20kW that uses non-renewable fuel (gasoil and natural gas), and whose heat transfer fluid is water. An annual control is established for oil boilers and natural gas boilers should have a control every two years since 2019. This control generates energy gains around 1% for gas boilers and 2% for oil ones. This measure lasts the whole projected period but the measures reaches only 10% of the total target.

The phasing out of fossil fuels such as coal and gasoil is considered in the WEM scenario. Starting from 2021, it will not be allowed to install any equipment using coal as fuel. Whilst this will be the case for gasoil installations from 2025.

Another measure considered in the WEM scenario is the energy grant system. The energy gains are estimated considering the average gain of 2009 to 2020 for building's isolation, double glazing implementation, heating regulation systems and boilers replacement. The energy gain is considered to last 20 years. This gain is multiplied by the annual budget; the WEM scenario considers the budget proposed by the Government from 2021 (31,2M€) to 2024 (47,5M€). According to the grant system report concerning the year 2018, residential sector benefits of 91% from total budget, this percentage was used to estimate the energy reduction of this sector and is kept constant.

Finally, Brussels Capital Region promoted from 2007 to 2013 the "Exemplary Buildings Project" (BatEx). The objective of the project was to promote ecological construction and passive buildings. The project allowed the construction and renovation of approximately 214.000 m^2 in the residential sector. The energy gain is estimated to last 20 years. The impact of the Exemplary Buildings Project will come to and end in 2033.

WAM SCENARIO

The WAM scenario considers the improvement or the widening of some measures taking place in the WEM scenario for the residential and tertiary sector. This is the case for the boiler's control, in the WAM scenario, the effectiveness of the measure increases to 25%. This increase of effectiveness is also apply to the technical reception of a new heating boiler.

Finally, the strategy for reducing the environmental impact of existing buildings, known as "Renolution" is considered in this scenario. The assumptions consider the acceleration of the renovation in old buildings

[16] 21 décembre 2007.- Arrêté du Gouvernement de la Région de Bruxelles – Capitale déterminant des exigences en matière de performance énergétique des bâtiments et du climat intérieur des bâtiments tel que modifié par l'arrêté du 5 mai 2011.

and the phasing out of coal, oil, CHP in 2040 and the phasing out of gas in the longer term in order to achieve the objectifs stated in the stratategy.

1.3.6 The tertiary sector (CRF category 1A4a)

Flanders

WEM scenario

A model adapted to the specifics of the tertiary sector is used for the tertiary energy projections. This model allows us to have adapted assumptions for each subsector. The following subsectors are defined: healthcare, trade, offices, education, restaurants, hotels, bars, government and others.

The evolution of the energy demand is based on the evolution of general activity in each specific subsector or, if not available, the projected GDP growth.

A business as usual scenario is defined for investments in energy-efficiency based upon the current amount of subsidies that are given. Regarding additional heat pumps the WEM-scenario for renewable energy is adopted.

WAM scenario

For the WAM scenario a gradual increase of the investments in energy efficiency is modeled. It is assumed that the implementation of the Flemish renovation obligation will lead to a significant increase in the renovation activity and thus resulting in increased investments in energy-efficiency measures. It is assumed that the renovation activity will steadily increase because of the time given to implement the obligation. In addition, an obligation for all buildings, regardless if transferred or not, to reach a certain energy performance level by 2030 is implemented which will further boost energy demand reductions.

The additional amount of heatpumps installed and the fuel switch realised is based upon the WAM-scenario for renewable energy. Thus, the WAM scenario includes:

- the implementation of additional energy saving measures as described in the PAMs reporting
- the impact of renewable energy policies.

Wallonia

WEM scenario

Different energy services (heating, hot water, cooling, and other services including cooking, private and public lighting, refrigeration, and other electrical devices) and technologies are defined for 7 subsectors (education, health, culture and sports, shops, private offices, public offices, datacentres).

The evolution of the demands is linked to employment growth.

Some renovations fuel switching are assumed, according to the results from support policies (UREBA, …).

For electric equipment, new technologies are described according to the best available technologies.

WAM scenario

WAM scenario for tertiary sector includes different measures:

- For all buildings, more heat will be produced by renewable energy (biomass, heat pumps, ….), in accordance with targets of Air Climate Energy Plan for 2030.

- For existing buildings, the targets of the "Long term Renovation Strategy"[17] and its intermediate objectives are taken into account. It will reduce the environmental impact of existing buildings. This strategy defines different objectives for energy efficiency of the envelope and the equipments of the existing buildings.

This scenario wil require the implementation of new measures or the improvement/widening of some measures taking place in the WEM scenario.

Brussels-Capital Region

WEM SCENARIO

The main consideration for establishing projections is the expansion of building surface due to the increase of employment as well as the information available in the regional energy balance. The increase of teleworking in future years is also taken into account.

The implementation of the Brussels Energy Performance of Buildings Decree[18] is reflected in the projections. This measure is applied for office and education buildings; it starts in 2018. All new buildings are considered nearly passive (15kWh/m^2.yr) and all the heavy renovated buildings must reach a very low energy level (45kWh/m^2.yr).

The first measure focuses on the big energy consumers. It contemplates the requirement of an energy audit in order to obtain the renewal of the environmental permit for establishments exceeding 3500 m^2 [(19)]. The energy audit allows a reduction between 7,3% to 7,88%of final energy consumption.

The decree concerning energetic audits has been approved the 8th December 2016[20]. According to this framework, the big companies, defined by the number of employees and its energy consumption, must do an energy audit starting on 2018, this means in average 18 additional audits per year. In addition, the target is enlarged for commercial establishments, starting from 2018; commercial establishments with a surface over 1500m^2 must do an energy audit.

In addition, there is the mandatory implementation of the local action and energy management plans (PLAGE, French acronym) in private buildings which surface exceeds 100.000 m^2 and public buildings with an area bigger than 50.000 m^2. The objectives of the PLAGE are to implement energy management measures, handle energy invoices, increase users comfort, improve air quality and reduce GHG emissions. This action starts on 2019. The first phase lasts 6 years and the subsequently phases have a duration of 4 years. The objective of the PLAGE is to obtain a reduction on final energy consumption of 10% per phase.

[17] https://energie.wallonie.be/fr/strategie-de-renovation.html?IDC=9580. For tertiary buiding: energy efficient and carbon neutral buiding for heating, production of domestic hot water, cooling and lighting in 2040

[18] 21 décembre 2007.- Arrêté du Gouvernement de la Région de Bruxelles – Capitale déterminant des exigences en matière de performance énergétique des bâtiments et du climat intérieur des bâtiments tel que modifié par l'arrêté du 5 mai 2011.

[19] 30 janvier 2012.- Arrêté du Gouvernement de la Région de Bruxelles-Capitale rélatif à un audit énergétique pour les établissements gros consommateurs d'énergie.

[20] Arrêté du Gouvernement de la Région de Bruxelles-Capitale relatif à l'audit énergétique des grandes entreprises et à l'audit énergétique du permis d'environnement approuvé en troisième lecture le 8 décembre 2016.

The impacts of the NRClick and the subsequent RenoClick programmes are also part of the WEM scenario. These programmes oriented for the brussels public services propose a complet renovation programme. It covers deep renovation but also energy efficiency projects or PV installation.

Three measures already described in the residential sector scenario (see section 1.3.5) are also applied in the tertiary sector. The first one is the technical control of heating systems which has the same hypothesis than the residential sector. The second one is the implementation of the energy grant system; the only difference is the proportion of the budget assigned to this sector; according to the grant system report concerning the year 2018, tertiary sector uses 9% of total budget and it is kept constant between 2019 and 2040. Finally, the BatEx project that promoted the energy and environmental performance, the profitability and reproducibility of the technologies, and the architectural quality and urban integration of buildings was also applied in the tertiary sector. In fact, approximately 396.000 m^2 were constructed and renovated under this project between 2007 and 2013. The energy reduction obtained thanks to the construction characteristics is assumed to remain for 20 years. The impact of the Exemplary Buildings Project will come to and end in 2033.

WAM SCENARIO

As mention before, the boiler's control effectiveness is increased to 25% in the WAM scenario.

Moreover, the strategy for reducing the environmental impact of existing buildings, known as "Renolution" is considered in this scenario. The assumptions consider the achievement of the neutrality in public buildings in 2040 considering the increase of the renovation rate and the phasing out of fossil fuels.

1.3.7 The agricultural sector (CRF category 1A4c and 3)

Greenhouse gas emissions in the agricultural sector mainly consist of CH_4 and N_2O emissions originating from animal husbandry and emissions from agricultural soils.

The livestock numbers mentioned in Table 1.9 were used in the projections.

		WEM						WAM					
Animal numbers (thousands)	**2019**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Dairy Cattle	497	491	478	478	478	478	478	488	475	475	475	475	475
Non-dairy Cattle	1.890	1.775	1.717	1.717	1.717	1.717	1.717	1.747	1.648	1.648	1.648	1.648	1.648
Sheep	138	133	140	140	140	140	140	131	139	139	139	139	139
Swine	6.224	5.075	4.503	4.503	4.503	4.503	4.503	5.059	4.472	4.472	4.472	4.472	4.472
Poultry	44.914	49.096	49.684	49.684	49.684	49.684	49.684	47.429	47.091	47.091	47.091	47.091	47.091

Table 1.9 : Livestock numbers used in the projections.

Flanders

In 2019 energy consumption in the agricultural sector mainly originates greenhouse heating systems (63%), non-stationary sources (fisheries, tractors, ...) (12%) and the warming of stables (25%).

Off-road emission projections are calculated using the OFFREM-model with emission factors of the IPCC 2006 guidelines (CO_2 and CH_4) and EMEP/EEA guidebook (N_2O). Emission projections of sea-fishery are calculated with the EMMOSS model. Both models are also used for the greenhouse gas inventory.

The WEM projections for the greenhouse horticulture take into account an extension of current subsidies[21] for energy efficiency and renewable energy measures. In the WAM scenario increase in the budget for the subsidy system in the period 2023-2030 has been taken into account.

The CH_4 and N_2O emission projections take all policy measures, listed in the PAMs reporting, into account and assumptions on the evolution of the animal herd.. The main policy measures that were included in the projections are briefly summarised below:

- Flemish covenant on enteric emissions in combination with the eco scheme feed management for methane reduction from the CAP strategic plan.
- The target of reducing the pig population by 30% by 2030 (to be met in part by a buy-back scheme) compared to 2015.
- Small-scale digestion applied to 30% of total dairy cattle, i.e. 50 % of dairy cattle in barns with manure pit (60 % of the dairy herd). This corresponds to 500 small-scale digesters on dairy farms in 2030.
- Small-scale digestion applied at 25% of the number of pigs in stalls with manure pit (100% of the pig population) taking into account the reduction of the pig population by 30%. This corresponds to 130 small-scale digesters on pig farms.
- Soil emissions are reduced, among others, through the new manure action plan MAP 7 which is still in draft stage. A more concrete calculation of soil emissions will be elaborated in the final update of the Flemish energy and climate plan. Implementation of the measures in the CAP strategic plan will lead to further reduced nitrogen fertilisation.

Wallonia

Energy related emissions in the agricultural sector in the Walloon Region, including the emissions from the gasoil of tractors and other mobile equipment, are limited (320 ktCO2e for the whole period).

CH_4 and N_2O emission projections take into account the recent evolutions of activity data:

- livestock: a global decrease for cattle and an increase for all the other animal categories in the WEM scenario; a further decrease of non-dairy cattle and a decrease in pigs and poultry for the WAM scenario
- fertilizer uses: a reduction of mineral fertilisers (further decrease in WAM) and an increase for the organic fertilisers.

For some parameters, the mean values of last years are maintained up to 2050, in absence of any other information (e.g. milk yield, crop residues, ...).

The calculations follow the methodology of GHG inventories, detailed in the National Inventory Report of the 2023 submission.

Brussels-Capital Region

Greenhouse gas emissions in the agricultural sector mainly consist of CH_4 and N_2O emissions originated from animal husbandry (enteric fermentation and manure management) and direct and indirect

[21] https://lv.vlaanderen.be/subsidies/vlif-steun-voor-de-land-en-tuinbouw

emissions from managed soils. The CH_4 and N_2O emissions of the agricultural sector are very low in Brussels Capital Region. The stabilisation of the sector is assumed since further expansion is not possible; thus the values remain constant.

1.3.8 The transport sector (CRF category 1A3)

Biofuels

The share of biofuels in transport fuels is one of the important factors determining the emission levels. The shares of biofuels used in the regional road transport models are harmonized on the basis of this federal PAM described in the 2019 National Energy Climate Plan. Table 1.10 provides an overview of the assumed blends of biodiesel in diesel and bioethanol in gasoline in the WEM and WAM scenarios until 2030. These are kept constant after 2030.

		2025	2030
WEM	bioethanol	8,95	8,95
	biodiesel	8,95	8,95
WAM	bioethanol	10	10,45
	biodiesel	10	10,45

Table 1.10 : Overview of the assumed energetic shares of biofuels in transport fuels in the WEM and WAM scenarios (% Net Calorific Value).

Apart from the harmonized shares of biofuels in road transport, the rest of the transport sector modelling occurs through specific regional models. These are described below.

Flanders

The transport sector includes road transport, railway transport, inland shipping, maritime shipping and air transport. Different models were used for the various transport modes. The models calculate the use of energy and the emissions starting from the transport flows (volumes). For road traffic, railway traffic and inland shipping a specialised traffic model was used to calculate the transport flows, the Flemish multimodal model.

Road transport

The calculation of atmospheric pollutants emissions and energy consumption for road transport is based on projection studies performed by VITO for the Flemish government using the Fastrace model[22]. Only motorized traffic (excl. pedestrians and cyclists) is included in the projections.

The GHG projections take 2019 as base year. The confirmed policies and measures are taken into account in the **WEM scenario**. These include the national and regional planned improvements of the public transport network, the redesign of some urban areas to promote soft transport modes (walking, cycling), and the implementation of trucks freight transport pricing. No new Flemish measures are assumed in the WEM scenario after 2019. Starting from the base year 2019, the expected evolution of mobility and transport demand in Flanders in the WEM scenario was used to calculate the number of vehicle kilometers

[22] https://vito.be/en/product/fastrace-traffic-emission-model

per vehicle type and fuel type for the period 2019-2030 and 2050. The total Flemish fleet composition was modelled for the period 2019-2030 and 2050 starting from the fleet in 2019 and considering the composition of new vehicles and survival rates of the vehicles over the same period.

Additional measures to reduce the number of vehicle kilometers and aiming at a significant shift to electric, plug in hybrid or charge sustaining hybrid vehicles, have been taken into account in the **WAM scenario**. Additional measures are expected to reduce the number of vehicle kilometers compared with the WEM scenario. The Flemish Clean Power for Transport Plan 2020[23] and Vision 2030 will lead to a shift towards cleaner vehicles. This includes a target of 100% zero emission vehicles (new sales) in 2029 both for cars and light duty vehicles.

Rail transport

Emissions of rail transport only include the emissions originating from diesel trains, while energy figures include energy use by electric trains as well. The applied growth in transported volumes determines train-kilometers, which in turn determine the evolution of the emissions. The shares of diesel and electric traction are considered constant over the projected period.

Inland Waterways and Short-sea Shipping

Emissions of inland waterways and short-sea shipping are based on the evolution of the transported volumes which determine the evolution of the emissions.

Off-road emissions

Emission of off-road activities in harbours, airports and transhipment companies are allocated to CRF category 1A3e. The emissions projections are calculated with the country-specific OFFREM-model with emission factors of the IPCC 2006 guidelines (CO_2 and CH_4) and EMEP/EEA guidebook (N_2O).

Pipeline transport

Emissions originating from the compression activities in the sector 'storage and transport of natural gas' are reported in CRF category 1A3e. These emissions are assumed to remain constant at the 2019 level.

Wallonia

Road transport

The projections of the overall mobility are calculated using the principle of mobility demand.

- Projections of the Federal Planning Bureau[24] are used for WEM scenario (demand is assumed to increase, with little modal shift)
- FAST programme is considered for WAM scenario: the FAST vision is an ambitious plan focused on mobility adopted by the Walloon government. It foresees a major modal shift towards rail transport and a reduction in the general demand for transport. For passenger cars, demand decreases under the impulsion of a decreasing modal share of cars (from 83% in 2017 to 63% in 2030), a rise in the car occupancy rate (from 1.3 in 2017 to 1.5 in 2030) and a reduction of 5% of

[23] https://www.vlaanderen.be/milieuvriendelijke-voertuigen/beleid (in dutch)

[24] For more information see: https://www.plan.be/publications/publication-2240-fr-perspectives_de_la_demande_de_transport_en_belgique_a_l_horizon_2040

the global demand for passenger transport. This scenario wil require the implementation of new measures or the improvement/widening of some measures taking place in the WEM scenario. Total demand for freight transport is kept constant for the whole period and the modal share by road is 77% in 2030 (84% in 2016).

In the WEM scenario, conventional vehicles remain the main technologies operating. In the WAM scenario, electric and hybrid vehicles rises in 2030. Hydrogen vehicles also appears after 2030.

Rail transport

In WEM scenario, we assume an increase of the emissions due to the increase of transport by rail.

In WAM scenario, despite a constant demand, the modal share for rail in the whole passenger transport rises until 16% in 2030 (9% in 2017). For freight transport, the modal share of train rises until 13% of the total freight transport in 2030 (9% in 2016).

Navigation

In WEM scenario, the demand increases for inland vessel transport of goods.

In WAM scenario, for navigation, the modal share for freight transport rises until 10% of the total tonnes.km in 2030 (7% in 2016).

Aviation

In WEM and WAM scenarios, demand for aviation is assumed to be related to the increase in population.

Brussels-Capital Region

WEM SCENARIO

Projections of transport emissions consider road and off-road transport, railways, inland navigation, and natural gas transport. Road transport emissions represent 93% of the total (direct) GHG emissions of transport (2020). The main hypotheses used for the projections are described in the following paragraphs.

Road transport

Projections of road transport emissions are calculated using a bottom-up approach (*fuel used* basis). The correction to *fuel sold* is applied as final step.

The model used starts from the last known vehicles fleet circulating on the Brussels road network, available from the emissions inventories. The projections of the evolution of the vehicles fleet are based on historical survival curves, combined with other constraints like LEZ exclusions. The mobility demand scenarios comes from the Good Move project of Brussels-Mobility (scenarios No Move [WEM scenario] and Good Move [WAM scenario]). New vehicles are added to the fleet if the existing fleet, combined with annual mileages, does not reach the total mobility demand.

The policies and measures taken into account for the simulations refer to WEM scenario. For road transport, the WEM scenario notably considers the implementation of a Low Emission Zone (LEZ), at the regional level, which implies that the vehicles that do not respect the established thresholds (based on fuel and EURO standards) are banned. Moreover, the government of the Brussels Capital Region has decided to implement a progressive phasing-out for fossil fuels-based thermic motors in the Region. Diesel light vehicles will be banned from 2030 on, and gasoline and GPL light vehicles from 2035 on.

At the current stage, this measure has a significant influence on some pollutants affecting local air quality, but a rather limited impact on GHGs emissions and climate change.

Rail transport

For railways, the evolution of liquid fuel (gasoil) consumption is derived from the evolution of freight transport demand at the Belgian level. The starting point of the projections (2019) comes from the regional energy balance. The GHG emissions increase of about 310 t CO_2 eq. between 2020 and 2030. Passengers transport (trains, metro and tramways) is driven by electricity; the increase on electricity consumption projected between 2020 and 2030 is 15%.

Navigation

For inland navigation, the evolution of liquid fuel (gasoil) consumption is derived from the evolution of freight transport demand at the Belgian level. The starting point of the projections comes from the regional energy balance. Projections show an increase of GHG emissions. In 2020, emissions from inland navigation were 1.82 kt CO_2-eq, and in 2030 they will be 2.38 kt CO_2-eq.

Natural gas transport

The emissions originating from natural gas transport are kept constant and equal to the emissions of year 2020 for the entire projection period since there are not available projections for this sector.

Off-road emissions

The projections of off-road emissions for all sectors and vehicles categories are calculated with the OFFREM model. This model has been developed for the 3 Regions in Belgium on the basis of a detailed bottom-up approach.

WAM SCENARIO

Road transport

The “Good Move” Plan[25] is the regional mobility plan. Developed through a dynamic and participatory process, Good Move defines the Region's mobility objectives and actions at the 2030 horizon. It focuses on six frames and is based on the implementation of fifty measures. According to preliminary estimates, the Good Move plan could contribute to a 21% reduction of vehicle-kilometers of light vehicles in the Brussels Capital Region from 2018 to 2030. The priority objectives of Good Move regarding energy and climate are to reduce the use and ownership of cars, increase the modal shift, and green the fleet.

1.3.9 The waste sector (CRF category 5)

Flanders

Projections of CH_4 emissions from the solid waste disposal on land in Flanders (CRF category 5A) are calculated taking into account a ban on organic waste dumping since 2000. CO_2 emissions from the solid waste disposal on land sites originate when recovered emissions are used or flared via installations with energy recuperation. These emissions are reported in the energy sector (CRF category 1A1a and 1A4a).

[25] https://goodmove.brussels/fr/

CH_4 and N_2O emissions from waste water handling in Flanders (CRF category 5D) are based on projections with respect to the evolution of population and of the number of people connected to waste water handling systems until 2050.

CO_2 emissions from municipal waste water treatment are set to zero in the projections because these emissions derive from biomass raw materials.

The waste incineration category includes incineration of municipal and industrial waste, incineration of hospital waste and the incineration of corpses. In Flanders, only the fraction of organic-synthetic waste is taken into consideration to estimate the CO_2 emissions originating from waste incineration. As mentioned in section 1.3.1 the projections of the waste incineration plants with energy recuperation are allocated to the energy sector.

CO_2 emissions from flaring in the chemical industry are allocated to the waste sector (CRF category 5C) and are assumed to remain constant at the 2021 level.

CH_4 emissions from composting in Flanders (CRF category 5B) are kept constant at current emission levels.

Wallonia

Projections of CH_4 emissions from the solid waste disposal on land in Wallonia take into account the implementation of the Order of the Walloon Government of March 18th, 2004 banning the dumping of municipal waste into landfills since January 1st, 2008, yielding a decline in degradable organic carbon (DOC) content (municipal waste being mainly organic).

Nevertheless, the amount of total waste disposed is considered constant and equal to the latest available data (average of the 5 latest years). The methodology used for calculation is the one described in the last 2006 IPCC guidelines and in the National Inventory Report of the 2023 submission. The recovery rate of landfill gas is assumed to remain constant and equal to the average of the 5 latest years. CO_2 emissions from the solid waste disposal on land sites come from the use of recovered emissions are used or flared via installations with energy recuperation. These emissions are reported in the energy sector.

CH_4 and N_2O emissions of wastewater handling in Wallonia are kept constant at current emission levels. CO_2 emissions from municipal wastewater treatment are not included in the projections because the carbon derives from biomass raw materials.

The waste incineration category includes incineration of municipal solid waste, incineration of hospital waste and flaring in the chemical industry. The CO_2 emission projections originating from hospital waste incineration are integrated in the waste incineration sector. The emission projections of the municipal waste incineration plants (with energy recuperation) are allocated to the energy sector.

CH_4 and N_2O emissions from composting in Wallonia are kept constant at current emission levels.

The figures reported under WEM and WAM scenario are the same.

Brussels-Capital Region

Waste sector takes into account the emissions from water treatment plants, composting installations, and waste incinerators. For the waste water handling emissions, only the N_2O emissions are considered in the projections since the biogas produced is used in a CHP installation. Projections are based on the population evolution (see section 1.2.4). The compost centre started in 2002 and the emissions from composting process are kept constant for the projected period. The waste incinerator of Neder-Over-Heembeek is not included in the waste sector due to the energy recovery process; this installation is included in the energy sector.

1.3.10 The land-use and land-use change and forestry sector (CRF category 4)

The approach for the LULUCF WEM projections consists of extrapolating the recent trends of land use changes towards 2050 on the basis of the most recently integrated data of the Land Use Change Matrix in the LULUCF emission inventory. Both CO_2 and N_2O emissions are taken into account. A technical correction of the Forest Reference Level will be prepared before the final accounting for 2021-2025. , as significant updates were applied in the GHG inventory. Hence, the accounting exercise made at Belgian level should be considered provisional.

Flemish Region

In the WEM scenario, the trend is adjusted for specific land use and land use change categories, based on the following hypotheses:

- There is zero net deforestation from 2021 onwards;
- There will be 4.000 ha of additional forest by 2024, and 10.000 ha by 2030, as compared to the forest area present in 2019.

The WAM scenario adds the following adjustments to the business-as-usual trend:

- The average net daily land take, i.e. conversion of land to settlements, is reduced to 3 ha per day by 2025 and to 0 ha per day by 2040;
- Carbon sequestration in agricultural land is promoted by application of certain techniques and crops, as included in the Common Agricultural Policy (CAP);
    - From 2023 onwards, 200.000 ha of cropland will have an annual increase of the soil carbon stock of 0.4%.
    - In the period 2023–2027, additional effective organic carbon (EOC) is supplied to cropland via adjusted annual cropping plans;
    - Additional buffer strips are installed, o.a. to protect against erosion, corresponding to an additional area of land converted from cropland to grassland.

Wallonia

The trend is adjusted for specific land use categories, based on these hypothesis:

- The land use change from grassland to cropland will stop from 2025 onwards, in line with the CAP.
- The trends in soil organic carbon will remain constant from 2030 onwards
- In Wallonia, the conversions to settlements is gradually reduced up to 2050, based on the last decree regarding territorial development and artificialization of soils

Brussels-Capital Region

LULUCF emissions are kept constant for the entire projected period in the Brussel-Capital Region.

1.4 Aggregated projections

1.4.1 The 'with existing measures' greenhouse gas emission projections

The following tables summarise the compiled 'with existing measures' projections for the period 2005-2050.

	2005	2010	2015	2019	2020	2021	2025	2030	2035	2040	2045	2050
Total excluding LULUCF	145,4	133,6	119,0	116,5	107,3	111,0	112,0	106,6	104,2	105,0	104,2	103,5
Total including LULUCF	143,7	133,3	118,1	116,0	106,9	110,6	111,3	105,5	103,0	103,9	103,1	102,3
EU ETS (in accordance with ETS scope 2013-2020)	66,5	54,8	44,7	44,6	41,5	41,4	44,0	42,7	42,1	43,2	43,3	42,9
ESD (in accordance with ETS scope 2013-2020)	78,9	78,8	74,3	71,9	65,8	69,5	68,0	63,9	62,1	61,8	60,9	60,6
LULUCF	-1,8	-0,4	-0,9	-0,5	-0,3	-0,3	-0,7	-1,1	-1,1	-1,1	-1,1	-1,1

Table 1.11: Greenhouse gas emissions by policy sector (WEM scenario) $MtCO_2$-eq.

	2005	2010	2015	2019	2020	2021	2025	2030	2035	2040	2045	2050
1 Energy	105,8	99,6	87,1	85,5	78,1	82,1	84,1	79,8	77,6	78,7	78,1	77,2
1A Fuel combustion	105,0	98,8	86,4	84,8	77,4	81,4	83,4	79,1	76,9	78,0	77,4	76,5
1A1 Energy industries	*29,0*	*26,1*	*20,8*	*21,0*	*19,0*	*18,2*	19,2	18,0	17,9	19,3	20,0	19,7
1A2 Manufacturing industries and construction	*18,9*	*16,0*	*13,8*	*13,9*	*13,3*	*14,0*	*14,9*	*14,8*	*14,0*	*13,7*	*12,7*	*12,2*
1A3 Transport	*26,7*	*26,7*	*26,9*	*26,0*	*21,7*	*23,9*	*25,5*	*23,2*	*22,2*	*22,1*	*21,7*	*21,5*
1A4 Other sectors	*30,1*	*29,9*	*24,7*	*23,9*	*23,3*	*25,3*	*23,7*	*23,0*	*22,6*	*22,8*	*22,9*	*23,1*
1A5 Other	*0,2*	*0,1*	*0,1*	*0,1*	*0,1*	*0,1*	*0,1*	*0,1*	*0,1*	*0,1*	*0,1*	*0,1*
1B Fugitive emissions from fuels	0,8	0,8	0,7	0,7	0,7	0,7	0,7	0,7	0,7	0,7	0,7	0,7
2 Industrial processes	26,5	21,7	20,5	19,9	18,4	18,2	17,6	16,8	16,8	16,7	16,7	16,9
3 Agriculture	9,9	9,7	9,7	9,6	9,5	9,4	9,3	9,1	8,9	8,7	8,6	8,5
4 Lulucf	-1,8	-0,4	-0,9	-0,5	-0,3	-0,3	-0,7	-1,1	-1,1	-1,1	-1,1	-1,1
5 Waste	3,2	2,6	1,7	1,4	1,3	1,3	1,1	0,9	0,9	0,9	0,9	0,9

Table 1.12: Greenhouse gas emissions by IPCC sector (WEM scenario) $MtCO_2$-eq

	2005	2010	2015	2019	2020	2021	2025	2030	2035	2040	2045	2050
CO_2	125,6	114,6	101,1	99,5	91,1	95,7	98,0	93,8	91,5	92,7	92,0	91,4
CH_4	9,6	9,1	8,5	8,1	8,0	7,9	7,5	7,0	6,9	6,8	6,7	6,7
N_2O	7,5	6,7	5,3	4,9	4,8	4,7	4,6	4,5	4,5	4,4	4,4	4,4
F-gases	2,6	3,2	4,0	4,0	3,4	2,7	2,0	1,2	1,2	1,1	1,1	1,1

Table 1.13: Greenhouse gas emissions by gas, excluding LULUCF (WEM scenario) $MtCO_2$-eq.

1.4.2 The 'with additional measures' greenhouse gas emission projections

The effect of the additional measures included in the WAM scenario results in the emission projections described in the following tables.

	2005	2010	2015	2019	2020	2021	2025	2030	2035	2040	2405	2050
Total excluding LULUCF	145,4	133,6	119,0	116,5	107,3	111,0	105,9	83,3	74,8	72,4	70,7	40,6
Total including LULUCF	143,7	133,3	118,1	116,0	106,9	110,6	105,0	82,0	73,5	71,0	69,4	39,3
EU ETS (in accordance with ETS scope 2013-2020)	66,5	54,8	44,7	44,6	41,5	41,4	43,1	36,5	30,3	31,4	31,5	26,9
ESD (in accordance with ETS scope 2013-2020)	78,9	78,8	74,3	71,9	65,8	69,5	62,7	46,8	44,5	40,9	39,2	13,6
LULUCF	-1,8	-0,4	-0,9	-0,5	-0,3	-0,3	-0,9	-1,3	-1,3	-1,3	-1,3	-1,3

Table 1.14: Greenhouse gas emissions by policy sector (WAM scenario) $MtCO_2$-eq.

	2005	2010	2015	2019	2020	2021	2025	2030	2035	2040	2045	2050
1 Energy	105,8	99,6	87,1	85,5	78,1	82,1	79,0	63,9	59,2	57,2	55,7	27,2
1A Fuel combustion	105,0	98,8	86,4	84,8	77,4	81,4	78,3	63,2	58,6	56,6	55,0	26,5
1A1 Energy industries	*29,0*	*26,1*	*20,8*	*21,0*	*19,0*	*18,2*	*19,1*	*17,3*	17,3	19,1	19,2	13,7
1A2 Manufacturing industries and construction	*18,9*	*16,0*	*13,8*	*13,9*	*13,3*	*14,0*	*13,8*	*13,0*	*9,8*	*9,5*	*9,5*	*8,0*
1A3 Transport	*26,7*	*26,7*	*26,9*	*26,0*	*21,7*	*23,9*	*23,5*	*16,6*	*15,6*	*14,4*	*13,1*	*0,6*
1A4 Other sectors	*30,1*	*29,9*	*24,7*	*23,9*	*23,3*	*25,3*	*21,8*	*16,3*	*15,8*	*13,5*	*13,1*	*4,1*
1A5 Other	*0,2*	*0,1*	*0,1*	*0,1*	*0,1*	*0,1*	*0,1*	*0,1*	*0,1*	*0,1*	*0,1*	*0,0*
1B Fugitive emissions from fuels	0,8	0,8	0,7	0,7	0,7	0,7	0,7	0,7	0,7	0,7	0,7	0,7
2 Industrial processes	26,5	21,7	20,5	19,9	18,4	18,2	17,2	11,1	7,2	6,8	6,7	6,3
3 Agriculture	9,9	9,7	9,7	9,6	9,5	9,4	8,7	7,5	7,5	7,5	7,5	6,4
4 Lulucf	-1,8	-0,4	-0,9	-0,5	-0,3	-0,3	-0,9	-1,3	-1,3	-1,3	-1,3	-1,3
5 Waste	3,2	2,6	1,7	1,4	1,3	1,3	1,1	0,9	0,9	0,9	0,9	0,7

Table 1.15: Greenhouse gas emissions by IPCC sector (WAM scenario) $MtCO_2$-eq

	2005	2010	2015	2019	2020	2021	2025	2030	2035	2040	2045	2050
CO_2	125,6	114,6	101,1	99,5	91,1	95,7	92,8	72,7	64,2	61,8	60,3	32,2
CH_4	9,6	9,1	8,5	8,1	8,0	7,9	7,0	5,7	5,7	5,7	5,7	4,7
N_2O	7,5	6,7	5,3	4,9	4,8	4,7	4,4	4,0	4,0	4,0	4,0	3,3
F-gases	2,6	3,2	4,0	4,0	3,4	2,7	1,8	0,9	0,9	0,8	0,7	0,3

Table 1.16: Greenhouse gas emissions by gas, excluding LULUCF (WAM scenario) $MtCO_2$-eq.

1.4.3 Results of the sensitivity analysis

Two parameters were varied in a sensitivity analysis (see Table 1.17): the number of heating days and the net imports of electricity. This leads to four scenario's: 1) warm scenario (low number of heating days as recorded in 2014), 2) cold scenario (high number of heating days as recorded in 2013), 3) lower electricity import (-25% compared to base scenario) and 4) lower electricity import (-75% compared to base scenario). For the four scenario's, the total WEM and WAM emissions were calculated (see Table 1.18).

Scenario	Number of heating days (2025-2050)	Net electricity import WEM [TWh]						Net electricity import WAM [TWh]					
		2025	2030	2035	2040	2045	2050	2025	2030	2035	2040	2045	2050
Base scenario	1.761	16,7	17,7	7,5	16,1	14,9	13,9	9,7	14,0	4,3	5,1	5,7	18,0
1: Warm scenario	1.441	16,7	17,7	7,5	16,1	14,9	13,9	9,7	14,0	4,3	5,1	5,7	18,0
2: Cold scenario	2.145	16,7	17,7	7,5	16,1	14,9	13,9	9,7	14,0	4,3	5,1	5,7	18,0
3: Low electricity import (-25%)	1.761	12,5	13,3	5,6	12,1	11,1	10,5	7,2	10,5	3,2	3,8	4,3	13,5
4: Low electricity import (-75%)	1.761	4,2	4,4	1,9	4,0	3,7	3,5	2,4	3,5	1,1	1,3	1,4	4,5

Table 1.17: Parameter values used for the sensitivity analyses.

Scenario	Total excl. LULUCF - WEM						Total excl. LULUCF - WAM					
	2025	2030	2035	2040	2045	2050	2025	2030	2035	2040	2045	2050
Base scenario	112,0	106,6	104,2	105,0	104,2	103,5	105,9	83,3	74,8	72,4	70,7	40,6
1: Warm scenario	109,1	103,8	96,5	91,7	90,7	90,5	103,1	81,3	64,9	45,1	42,5	38,6
2: Cold scenario	115,5	109,9	98,0	95,6	94,8	94,7	109,1	85,5	67,1	46,3	43,6	39,3
3: Low electricity import (-25%)	113,7	108,2	105,7	106,5	105,7	105,0	106,8	84,5	76,0	73,6	71,9	41,8
4: Low electricity import (-75%)	116,9	111,2	108,7	109,6	108,8	108,0	108,7	86,9	78,4	76,0	74,3	44,2

Table 1.18: Greenhouse gas emissions excluding LULUCF for the different scenario's of the sensitivity analysis, $MtCO_2$-eq.

1.5 Conclusion

1.5.1 Overall emission levels

There is a clear decrease between 1996 and 2021 in the total greenhouse gas emissions in the inventory (Figure 1-1). The total emissions in the WEM scenario show a slight decrease in the period 2020-2050. The total emissions in the WAM scenario show outspoken decrease in the periode 2020-2050. These projections do not include emissions nor removals from LULUCF.

Uncertainties concerning exogenous variables such as economic growth, climate conditions and electricity imports exist and their level will influence the resulting greenhouse gas emissions.

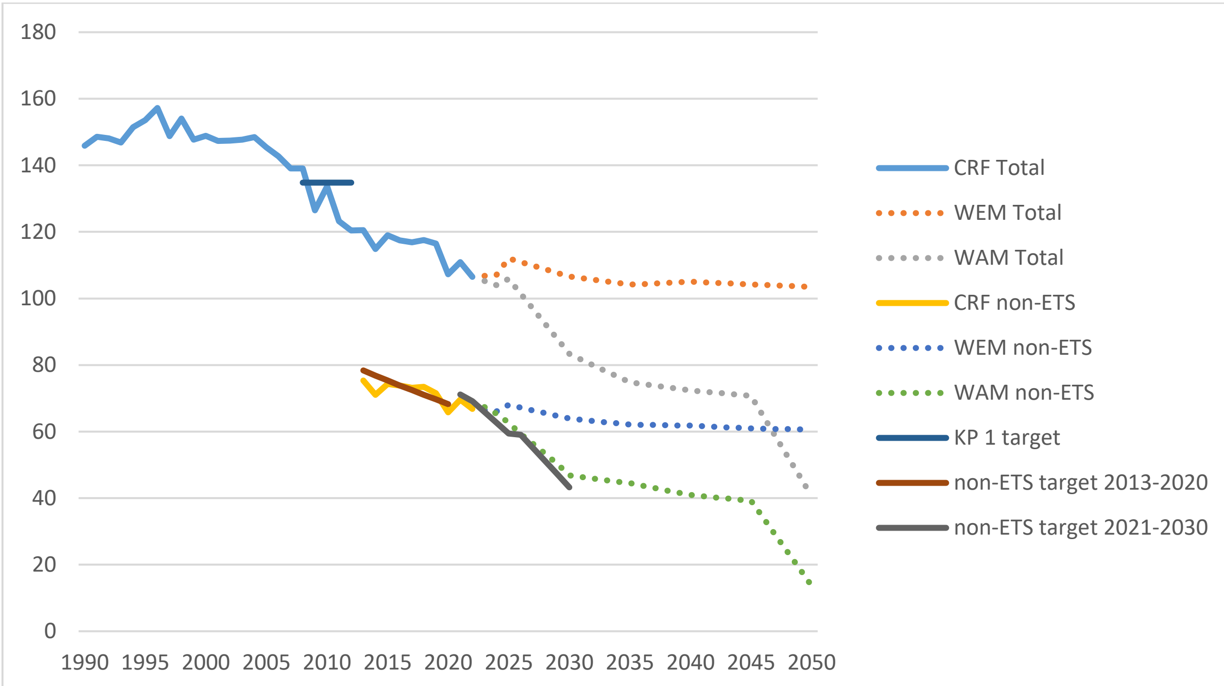


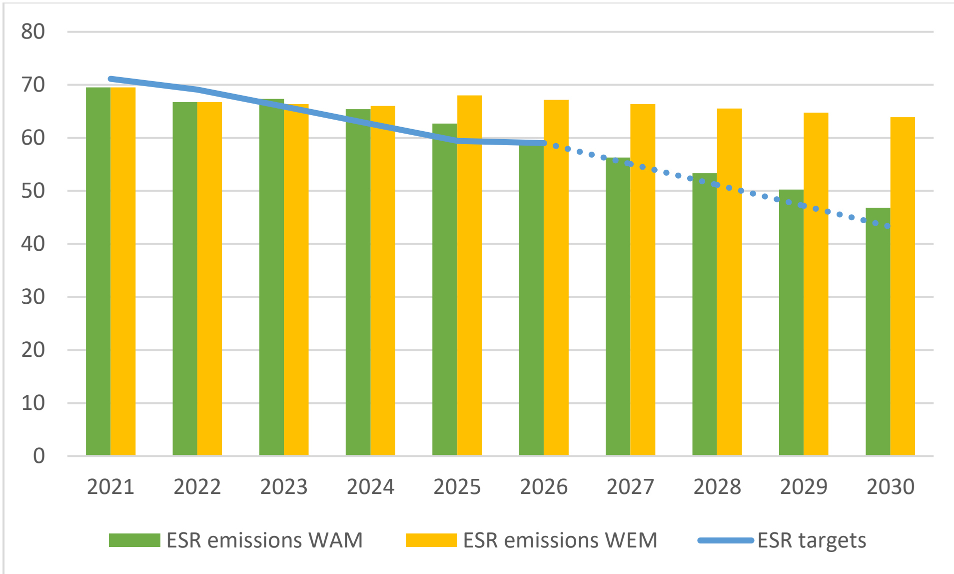
Figure 1-1 : GHG emissions excluding LULUCF (Mton CO_2-eq)

The amended EU Effort Sharing Regulation[26], establishing binding annual greenhouse gas emission reductions by EU Member States from 2021 to 2030, includes a target of -47% in 2030 compared to 2005 for Belgium.

1.5.2 Comparison with the Effort Sharing Regulation target (2021-2030)

In Figure 1-2, the ESR emissions of the WEM scenario and the WAM scenario are compared with the ESR emission target. Interpolation was used to determine the emission projections in the years 2022-2024 and 2026-2029 of the WEM scenario. In the WEM scenario, the ESR targets are exceeded from 2023 onwards. On an annual basis, the shortfall increases to 21 Mton CO_2-eq in 2030. Cumulated over the period 2021-2030, a deficit of 81 Mton CO_2-eq is expected. In the WAM scenario, the ESR targets are exceeded from 2023 onwards. On an annual basis, the shortfall increases to 4 Mton CO_2-eq in 2030. Cumulatively over the period 2021-2030, a shortfall of 14 Mton CO_2-eq is expected.

[26] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32023R0857



Source ESR targets :2021-2022 and 2030 in line with Commission Implementing Decision (EU) 2020/2126[27], 2023-2025 in line with Commission Implementing Decision (EU) 2023/1319[28] and 2026-2029 (own calculation, preliminary estimate) in line with Regulation (EU) 2023/857[29].

Figure 1-2 : Comparison of WEM and WAM ESR projections with ESR target (2021-2030) (Mton CO_2-eq)

27 https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32020D2126

28 https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32023D1319

29 https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32023R0857

Annex 1. Description of used models

I. Flemish energy and greenhouse gas simulation model

A new Flemish simulation model has been developed in 2014 (and is continuously updated since) to construct short term projections for Flanders.

The simulation model is a projection model for energy demand, greenhouse gas emissions and emissions of air pollutants (SO_2, NO_x, PM and VOC) that covers most of the relevant emission sectors (energy sector, industry, waste, agriculture, residential and commercial buildings).

This simulation model works as a "bottom-up" type, i.e. explaining energy consumptions and emissions from activity variables expressed as far as possible in physical units, and the main determining factors of the evolution of energy demand and emissions.

The model, which includes a database on the energy consumption, emission factors, activity data and reduction effects of climate & energy and air quality policy measures, can be used in particular for:

- the construction of a reference scenario (business as usual), representing the expected future evolution in the absence of any new emission reduction policy based on expected economic and demographic evolutions;
- constructing emission reduction scenarios, based on the implementation of a combination of reduction measures;
- assessing the impact of existing or draft legislations on energy consumption and emission levels.

The model starts from reference year data:

- energy demand per industrial sector;
- emissions per industrial sector;
- large combustion plants and all electricity producing plants are included at installation level (energy consumption, electricity production and emissions);
- detailed information on the evolution of the installed power for electricity generation (including electricity import);
- a representation of the structure of the residential heating (type and age) and of residences (idem for the heating of tertiary buildings).
- Share of the emissions, per sector, that comes from processes (and thus is not related to fuel consumption).
- For the agricultural emissions (dust, greenhouse gasses and ammonia emissions coming from stables and from manure), the starting point is the number of animals (detailed per animal category and per type of stable) and the amount of manure that is spread out.

For the residential sector, projections are driven by assumptions on degree days in the future, the share of new residences and the lifetime of existing installations. Policies on energy efficiency and on ecodesign are taken into account.

For industry, major assumption are the evolution of industrial activity and energy efficiency (yearly growth rate per sector), the share of CHP per sector and the lifetime of installations (since new installations mostly can respect lower emission levels than the existing ones). This leads to a projection on energy consumption and electricity.

Electricity demand from all sectors (including transport) is the main driver for the electricity part of the model. The model searches for the most cost optimal mix of electricity generating installations (including import) to produce the necessary electricity, taking into account different time slices (electricity demand is not equal in winter and in summer, neither during night or day), based on production efficiencies and fuel cost. The model has the possibility to install additional production capacity (CCGT or gas turbine).

For all energy consuming sectors, energy consumption is translated into emission projections through emission factors (per fuel) that reflect policy (either current policy or additional measures). For industry and electricity production, current emission factors are compared to the emission factors based on policy and the lowest of both is used (installations that already comply with future emission standards don't need to realize additional reductions). For the residential sector, the emission factors take into account the use of different types of boilers and stoves.

For the agricultural sector, the predicted number of animals is multiplied with animal specific emission factors (both for the greenhouse gasses as for ammonia and dust). These emission factors are lower for the new low emission stables. The amount of manure that is spread out is multiplied with specific emission factors.

II. FASTRACE[30] (Road transport in the Flemish Region)

FASTRACE is a software tool implemented by VITO to calculate spatially disaggregated emissions (on line segments) from road transport for a region of interest. The output of FASTRACE is designed for use as input to urban scale air pollution models.

FASTRACE starts from a detailed break-down of the vehicle fleet on the one hand (number of vehicles per vehicle type, annual mileage per vehicle type) and from geographically explicit vehicle counts per road segment on the other hand (number of passing vehicles per road segment and the associated speed). This data is often provided by a software tool that can simulate the flow of traffic (e.g. VISUM).

The emissions within FASTRACE are estimated based on country or region specific emission factors extracted from COPERT, the software used worldwide to calculate emissions from road transport. As the vehicle speed determines the emission factor to a large extent, FASTRACE also takes this parameter into account and employs speed dependent emission factors. FASTRACE offers numerous flexibilities in calculating detailed geographically distributed emissions for road transport, both for small and large regions.

III. Modelling tools in the Walloon Region

1. TIMES-Wal

A new model, called « TIMES-Wal » has been developed for Wallonia since 2016. After a transition period, he model is used for the first time for reporting purposes for WEM and WAM scenarios. TIMES-Wal model has been built in close collaboration between public (the Public Service of Wallonia) and private actors (ICEDD and E4SMA).

The TIMES model generator was developed by IEA-ETSAP (International Energy Agency-Energy Technology Systems Analysis Program). TIMES belongs to the "bottom-up" energy system models: it is based on a detailed technological set with associated costs and technical parameters. TIMES is an integrated model: one change in a sector can impact any other sector. TIMES is an optimization model: it must satisfy all energy service demands and constraints while minimizing the costs. In TIMES, perfect

[30] https://vito.be/en/product/fastrace-traffic-emission-model

foresight (i.e. all future events within the defined temporal horizon are known) and competitive markets are assumed.

The model is calibrated in order to best reflect the energy consumption data provided in the regional energy balance and the emission inventories. For all energy consuming sectors, energy consumption is translated into emission projections through emission factors (per fuel). At this stage, the model is fully calibrated for the year 2018 and later data is integrated through additional constraints, demand evolution,…

TIMES-Wal is a single region model. The interactions with other regions and countries are modelled through exogenous import and export processes. The temporal horizon is 2050.

TIMES-Wal does not include all the regional emissions. The model considers only the combustion emissions of the main regional sectors described in the model (which account for most of the combustion emissions).

For reporting purposes, specific sectoral discount rates are considered.

The energy system is divided into 7 main sectors: residential, commercial, industrial, transport, agricultural (only combustion), supply and electricity generation. The model uses very detailed regional data coming from regional studies. Updating models on the basis of the best available data, collected through studies or actors, is an important point of attention.

- Residential

The residential sector modelling is based on a comprehensive typology of buildings (20 categories of existing buildings depending on the period of construction and on the number of facades, and distinguishing apartments and houses). For each category, building surfaces are described and net needs for space heating and hot water are differentiated.

The evolution of demand for new buildings is defined according to the expected growth in the number of households. For those new buildings, specific net needs take into consideration that new buildings are more and more efficient according to the existing regional regulation.

In addition to hot water and space heating, other energy services are defined: lighting, cooking, refrigeration and freezing, cloth washing and drying, dish washing and other electricity services.

To satisfy all the demands, a set of technologies is described through the standard parameters: type of commodity, stock, efficiency, availability factor, lifetime, etc.

The model can choose to invest in four types of retrofitting options (walls, roof, windows, and ground renovation). The retrofitting options are differentiated according to the 20 categories of buildings.

- Commercial

The evolution of demands is linked to employment growth.

The commercial sector is divided into 7 subsectors: education, health, culture and sports, shops, private offices, public offices, datacentres. Different energy services are defined: heating, hot water, cooling, and other services including cooking, private and public lighting, refrigeration, and other electrical devices.

Demands are defined here in PJ (detailed data on surfaces for the commercial sector are not available). The structure of the sector is very similar to the residential one: the base year technologies and new technologies are defined, and retrofitting options are also included.

- Industry

The future evolution of demands is driven by hypotheses on economic activity.

The industrial sector is divided into 20 subsectors: milk, sugar, transformed potatoes, other food industry, cement, lime, hollow glass, flat glass, bricks, ceramics, other non-metallic minerals, ammonia, other chemicals, wood industry, pulp and paper, iron and steel, non-ferrous metals, non-energy consumption (chemicals and others) and other industries.

The industrial sector is modelled with data on each specific sub-sector (costs, temporal availability of new technologies, …) and accurate data on production processes.

- Transport

Concerning road transportation, demands are described in terms of passenger-kilometres or in tonnes-kilometres. For the other transport modes, the demand is simply described in terms of energy demand.

As in typical TIMES models, individual modal travel demand is exogenously defined over the model time horizon. While technologies can compete within modes based on technical parameters and cost, there is no competition between modes.

The TIMES-Wal transport sector includes a stock of technologies, in competition, that contribute to meet each exogenously defined modal travel demand. Regarding aviation, railways and domestic navigation, only one generic technology is described.

- Agriculture

For the agriculture sector, only the combustion-related part is included in TIMES-Wal model. Different energy services are defined: electric appliances, house heating and off-road.

- Electricity generation

Electricity demand from all sectors is a main driver for the electricity part of the model.

Every year is divided into time slices in order to best reflect variations in the load curve for electricity demand and intermittent energy sources. Each representative day is divided into multiple periods in order to consider different day and night times.

The electricity generation sector is described in detail and regroups all the main activity producers, that is those generating electricity (and heat) for sale to third parties through the grid. Three main types of producers are separately regrouped: the nuclear, renewable and thermal power plants.

Concerning new technologies, the model can make its choice on a varied list of new plants (gas power plants, renewable energy plants, …) based on technical parameters and costs.

For belgian reporting purpose "TIMES-Wal" is only used to model renewable and CHP (the rest being modeled on a Belgian scale).

2. Excel tools

Excel tools are used by Wallonia to estimate some sectors non included in TIMES-Wal: agriculture (excluding energy) and waste. For agriculture, different parameters are used to estimate the evolution of activity data (for example: livestock, agricultural area and fertilizer uses). For waste, the analysed parameters are the amount of total waste disposed, the recovery rate of landfill, CH_4 and N_2O emissions of wastewater handling, etc.

IV. Energy and Atmospheric Emissions projection model for Brussels Capital Region

Brussels Environment has developed an energy and emission projection model for the Brussels Capital Region. The model is developed in Excel and it is a bottom-up type model. It is compose of 4 main sectoral modules: Industry, Residential, Tertiairy and Energy Production. The model has been calibrated for each sector with the regional annual energy balances from 2000 to 2020. The modelled energy consumptions have then been converted into atmospheric emissions through emission factors, the ones used to establish the emission inventories. The model produces information for serveral energy carriers such as: natural gas, light oil, propane/butane, coal, electricity, wood, heat; and for several pollutants: CO_2, CH_4, N_2O, NOx, NMVOC, SOx, NH_3, $PM_{2.5}$.

The model also takes into account the direct emissions that are not related to energy consumption: i.e. the fugitive methane emissions of natural gas delivery, the industrial processes ans product use, and waste (composting plant, water purification plant).

This model is a dynamic one. It allows new available data to be integrated (for instance future energy balances) as well as new assumptions reflecting new studies and new phenomena (in the fields of regulation, technological change, through awareness campaigns, incentives, or the evolution of energy costs, among others.

Each sector is defined by different parameters that impact the future development as shown in Figure 1-3.

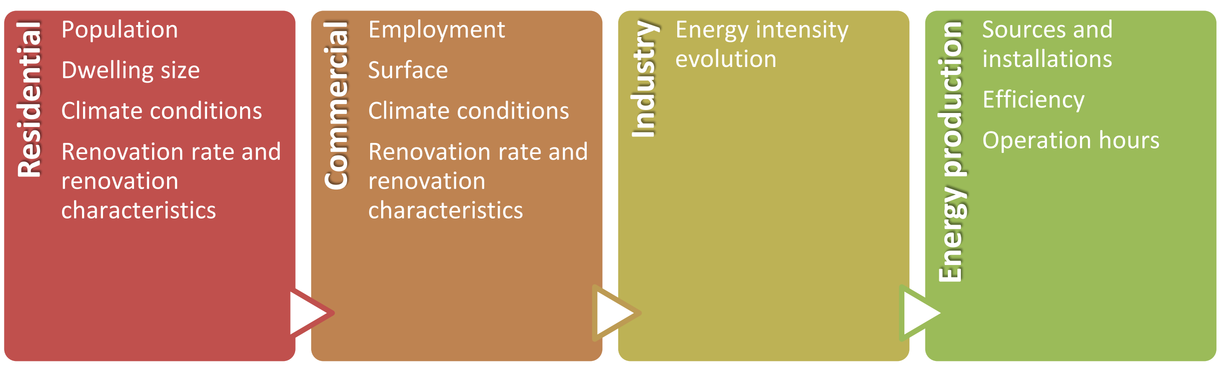


Figure 1-3. Key parameters for projections

V. Transport Emission Projection model for Brussels-Capital Region

The calculation of atmospheric pollutants emissions and fuels consumption for road transport is based on the European COPERT IV approach. The model used starts from the last known vehicles fleet circulating on the Brussels road network, available from the emissions inventories. The projections of the evolution of the vehicles fleet are based on historical survival curves, combined with other constraints like LEZ exclusions. The mobility demand scenarios comes from the Good Move project of Brussels-Mobility (scenarios No Move [WEM scenario] and Good Move [WAM scenario]). New vehicles are added to the fleet if the existing fleet, combined with annual mileages, does not reach the total mobility demand..

The Good Move scenarios have been simulated with the Multimodal strategic displacement model for BCR (MUSTI), which allows a mathematical modelling of passengers' behaviour in the BCR during a regular working day. The model is based on surveys and counting that provides a precise view of the mobility situation in the region. MUSTI is calibrated with a variety of observations. The counting shows, as precisely as possible, the displacement per road section, per vehicle type and per hour as well as the chosen itineraries. The model calculates the mileage focusing in the rush hours (morning 6h-10h and evening 15h-19h).

Pollutants emissions calculations with COPERT have been processed using the same software version and hypotheses as for the UNFCCC 2021 GHG inventory preparation. Fuels consumption are detailed for gasoline, diesel, LPG, CNG and electricity. In Belgium, biofuels are mixed with gasoline and diesel in public fuel tank stations (blends). The CO_2 emissions from the biogenic part of fuels (bioethanol or biodiesel) are calculated on the basis of the composition of blends, which may vary from year to year.

For railways, the evolution of liquid fuel (gasoil) consumption is derived from the evolution of freight transport demand at the Belgian level. The starting point of the projections comes from the regional energy balance. Pollutants emissions are calculated by combining fuel consumptions with emission factors from IPCC 2006 Guidelines for national emission inventories.

For inland navigation, the evolution of liquid fuel (gasoil) consumption is derived from the evolution of freight transport demand at the Belgian level. The starting point of the projections comes from the regional energy balance. Pollutants emissions are calculated by combining fuel consumptions with emission factors from IPCC 2006 Guidelines for national emission inventories.

VI. Off-Road Emission model (OFFREM)

The emissions from off-road are estimated using the OFFREM model (OFF-Road Emission model), which is used by the three regions. This makes it possible to report emissions for Belgium in a coherent manner in the context of mandatory international reporting.

Both exhaust and non-exhaust emissions by non-road mobile machinery are calculated for each sector separately, based on statistical data. Emissions are estimated based on detailed energy consumptions of non-road mobile machines and vehicle kilometres of non-road vehicles, according to following methodology:

- Exhaust emissions
    - Technology related pollutants (NO_x, VOC, NMVOC, CH_4, CO, N_2O, NH_3, PM and benzene)
        - Mobile machines: emission factors from EMEP/EEA for non-road mobile machinery are used (EMEP/EEA 2017).
        - Non-road vehicles: emission factors are derived COPERT IV (version 11.4) calculations for speeds of 15 km/h.
        - Emission factors for passenger cars on CNG are added, based on COPERT IV calculations. Euro 4 up to Euro 6 are available. For Euro 6DTemp and Euro 6 the emission factor for Euro 6 is kept.
        - EC emissions are added. f-BC (fraction of BC within PM) reported inthe EMEP/EEA methodology is used for machinery. For vehicles, the f-EC (fraction of EC within PM2,5) is calculated based on COPERT IV (version 11.4) for speeds of 15 km/h.
    - Fuel related pollutants (SO_2, CO_2, heavy metals)
        - Biofuels: as from 2009 biofuels are mixed into commercially available fuels. Within the offroad sector, equipment on diesel is assumed to use red diesel, and thus no biofuels are present. For equipment on petrol the Belgian fuel mix for road transportation is assumed. The fuel mix in weight percentage can be adapted per year, sector, fuel type and machine vs vehicle.

        - SO_2 and Pb emissions depend on the sulphur and lead content of fuels used. For this purpose, the parameters used in the COPERT runs for the Belgian emission calculations for road transport are applied.
        - CO_2 emissions depend on the fuel type. IPCC emission factors are applied.
        - Heavy metals also depend on the fuel consumption. Tier 1 emission factors per fuel type from EMEP/EEA for non-road mobile machinery (2017, Table 3-1) are used. For CNG and LPG, emission factors derived from COPERT IV are applied.
    - PAH/POP:
        - Mobile machines: Tier 1 emission factors in mg/kg fuel from the EMEP/EEA Air Pollutant Emission Inventory Guidebook for non-road mobile sources and machinery are applied (EMEP/EEA 2017, Table 3-1).
        - Non-road vehicles: bulk emission factors in µg/km for the EMEP/EEA Air Pollutant Emission Inventory Guidebook for road transportation are applied (EMEP/EEA 2016a, Table 3-75). Note that these emission factors are no longer based on the fuel consumption, as was the case in OFFREM I.
- Non-exhaust emissions: emissions of PM (brakes, tyres, road surface, clutches, chassis and shovel) are included.
    - Mobile machines: non-exhaust emission factors of CARBOTECH are implemented (Carbotech, 2000).
    - Non-road vehicles: EMEP/EEA Tier 2 non-exhaust emission factors and size distributions are applied for PM emissions, as used in calculating road transport emissions in the Belgian emission inventory (EMEP/EEA 2016b, Tables 3-4 and 3-5 for tyre wear, Tables 3-6 and 3-7 for brake wear and 3-8 and 3-9 for road surface wear). For heavy vehicles (trucks and buses) a load factor of 100% is assumed. To calculate the emission of non-exhaust heavy metals, the mean value of the weight fraction in table 3-12 is implemented.
    - Only resuspension emissions for the sector 'agriculture' are included.

VII. F-gas projections

F-gas projections are made through separate study assignments. In the most recent projection study[31], the methodology per sector is explained in detail. In general, it can be stated that the projection of F-gases is based on the same methodology as the emission inventory. It also uses assumptions consistent with those of this inventory. The projections have been established simultaneously for Belgium and for each of the three Regions, on a harmonised basis (regarding methodology and assumptions), in the same way as for the emission inventory. This means that when there is uncertainty on a parameter, as long as there is no evidence of a difference between regions on the value of that particular parameter, a common value has been chosen.

All calculations have been performed by extrapolating into the future the calculation models of the emission inventory, year by year, from 2021 up to 2050, which allows to consider changes in parameters occurring between the 5 yearly projection years, as well as the dynamic aspects of yearly stock changes.

It should be stressed that there are many uncertainties. The projections are not meant to be forecasts, they are based on many assumptions and should be considered as a possible future, given the anticipated

[31] https://www.cnc-nkc.be/sites/default/files/report/file/final_report_2022_public_-_projections.pdf

legislative context. In the context of these uncertainties, a conservative approach has generally been pursued, i.e. the assumptions made generally tend to overestimate rather than underestimate the emissions.

The calculation method is specific to each sector. All sectors of the emission inventory have been considered, even the smallest ones, which ensures complete consistency with the inventory.

VIII. Crystal Super Grid power model

The CRYSTAL SUPER GRID power model is developed by Artelys[32] and belongs to the family of unit commitment optimal dispatch models. These are models in which the optimal mix of generation technologies in a given area (country, region, continent, etc.) is determined as a function of demand. The optimal mix corresponds to the configuration where total production costs for the are minimized, and electricity demand is covered by production at all times, given a certain production, taking into account a certain number of technical and physical system limits.

These technical and physical limits may concern power plants (maximum efficiency, ability and/or speed and/or speed of start-up and power adaptation, etc.), interconnection (possibility and capacity of electricity exchanges with a neighbouring country), demand management (possibility of shifting part of the electricity demand over time, or even erase it), etc.

Unit commitment' refers to the process of determining which units are activated at which times and are therefore able to produce electricity. The decision may be made by the operator (in the case of thermal power plants), but activation can also be the result of a fortuitous phenomenon (for units dependent on weather-dependent units such as wind turbines or solar panels). As for “Economic dispatch”, it refers to the actual production of the various power plants successively activated, according to the cost-effectiveness criterion.

Belgium is not modelled as an isolated island: interactions with the power systems of the countries of the CWE zone (Central Western Europe) and Southern Europe (Portugal, Spain and Italy), which in turn must ensure a balance between supply and demand at all times, while taking into account a number of technical and physical constraints. As a result, the optimal electricity mix is not determined at Belgian level alone. If it is more cost-efficient to operate a power plant abroad and import surplus electricity (electricity that is not needed to cover demand in the country of production), this possibility must also be included in the calculations.

Unit commitment optimal dispatch models use relatively complex optimization algorithms, given the very high number of possible combinations of active and inactive generation units in the power system, for each unit of time. Typically, the time period studied is the whole year, hour by hour, so that 8760 time units are examined. The time horizon covered by the model can vary from short-term (e.g., 1 to 3 years) to long-term horizon (e.g., to 2030).

[32] https://www.artelys.com/crystal/super-grid/