Integrated reporting on greenhouse gas policies and measures and on projections in the Czech Republic

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CONTENT

EXECUTIVE SUMMARY

The Czech Republic is a Party to the United Nations Framework Convention on Climate Change (UNFCCC), the Kyoto Protocol and the Paris agreement. Under these international agreements it is committed to provide annually information on its national anthropogenic greenhouse gas (GHG) emissions by sources and removals by sinks for all GHGs not controlled by the Montreal Protocol. As a member of the European Union, the Czech Republic has reporting obligations also under the Regulation (EU) No 2018/1999 of the European Parliament and of the Council on the Governance of the Energy Union and Climate Action, amending Regulations (EC) No 663/2009 and (EC) No 715/2009 of the European Parliament and of the Council, Directives 94/22/EC, 98/70/EC, 2009/31/EC, 2009/73/EC, 2010/31/EU, 2012/27/EU and 2013/30/EU of the European Parliament and of the Council, Council Directives 2009/119/EC and (EU) 2015/652 and repealing Regulation (EU) No 525/2013 of the European Parliament and of the Council.

The Czech Republic also biannually fulfils obligations to Regulation (EU) No 2018/1999by submitting *Reporting on policies and measures and of projections of anthropogenic greenhouse gas emissions by sources and removals*. The reporting is organized and supported by the Czech Hydrometeorological Institute (CHMI) and the Ministry of Environment (MoE). The projections encompass two scenarios "with existing measures" (WEM) and "with additional measures" (WAM) according to guidelines published in the document FCCC/CP/1999/7, part II UNFCCC *Reporting Guidelines on National Communication,* and further in the above-mentioned EU documents. The reference year for both scenarios is the latest year for which emission estimates are available. In this case, the latest reporting year is 2018. The projection years are 2020, 2025, 2030, 2035, 2040, 2045, and 2050.

1. Policies and Measures

1.1. Cross-cutting Policies and Measures

Following chapter describes Policies and Measures (PaMs) which have impact at least on two from five sectors (1. Energy, 2. Industrial Processes and Product Use (IPPU), 3. Agriculture, 4. Land Use, Land Use Change and Forestry (LULUCF) and 5. Waste).

1.1.1.1. Integrated Prevention Act (288/2013 Coll.)

GHG affected: CO_2

Type of policy: Regulatory

Implementing entity: Ministry of Industry and Trade (Government)

Period of implementation: 2003 - 2035

Implemented in scenario: WEM

Sectors/Categories: 1.A.1. Energy industries; 1.A.2. Manufacturing industries and construction; 2. Industrial processes and product use

Characteristics of PaM: Transposition of the Directive 2010/75/EU on industrial emissions (integrated pollution prevention and control) (Recast) amending and subsequently repealing Directives 96/61/EC and 2008/1/EC.

The law provisions of amended Directives were obligatory for new installations from the year 2003 and for existing installations from the year 2012. The new Industrial Emissions Directive (IED) is applied from 2016.

The IED sets stricter emission limits for selected basic pollutants (in comparison to repealed Directives) and requires use of the Best Available Technologies/Techniques (BAT).

The IED aims at minimizing pollution from various industrial sources. Operators of industrial installations operating activities covered by Annex I of the IED are required to obtain an integrated permit from the authorities in the EU countries.

The permit conditions including emission limit values (ELVs) must be based on BAT and the documentation on the emission levels associated with it shall be the reference for setting permit conditions.

The Directive is implemented into the Czech legislation by the Act on Integrated Prevention and Pollution Control (IPPC) No. 69/2013 Coll. amending the Act No. 76/2002 Coll. Is further complimented by the Act on integrated prevention No. 288/2013 Coll.

Mitigation impact: The Act has an indirect impact on GHG emissions through the emission limits for basic pollutants and through the use of BAT. The strict emission limits are expected to have an important impact especially on coal-fired power plants and combined power and heat plants. The CO_2 emission reduction is derived from expected decommissioning of electricity and heat sources.

Tab. 1-1 Expected emissions reduction of IPPC (IED)

	2015	2020	2025	2030	2035
Emissions reduction [kt CO_2]	500	2 600	2 746	2 746	2 746

Additional information: The effects and costs were calculated according to the study "Podkladová analýza pro transpozici kapitoly III a přílohy V směrnice 2010/75/EU, o průmyslových emisích do nového zákona o ochraně ovzduší" prepared in 2011 by the company ENVIROS, Ltd. in cooperation with the CHMI and the company Brucek, Ltd., according to the ENVIROS, Ltd. model calculation results. It is expected that this Act has forced emission polluters not only to phase-out or reconstruct some less efficient and outdated facilities (e.g., installation of new boilers) but also to switch from coal to cleaner fuels like natural gas or biomass.

1.1.1.2. EU Emissions Trading Systems (EU ETS)

GHG affected: CO_2, N_2O, PFCs

Type of policy: Economic

Implementing entity: Ministry of Environment (Government)

Period of implementation: 2005 – 2040

Implemented in scenario: WEM

Sectors/Categories: 1.A.1. Energy industries; 1.A.2. Manufacturing industries and construction; M. International aviation in the EU ETS; 2. Industrial processes and product use

Characteristics of PaM: The EU ETS is one of the most important economic tools to reduce GHG emissions. The scheme for GHG emission allowance trading within the Community is established in Directive 2018/410/EU amending Directive 2003/87/EC, and Decision No. 2015/1814/EU

This legislation is transposed into the Czech legislation by Act No. 1/2020 Coll. on conditions for trading of emission allowances amending Acts No. 383/2012 Coll. and No. 458/2000 Coll.

Time framework: There have been agreed four trading periods. During the first (2005 – 2007) and the second (2008 – 2012) periods were allowances allocated free of charge in the Czech Republic. In the third period (2013 – 2020) there is a single EU-wide cap and allowances are allocated on the basis of harmonized rules. The single EU-wide cap on emission allowances replaces the previous system of national caps. The cap is cut each year (by 1.74%) so that by 2020 emissions will be 21% below the 2005 level. The free allocation of allowances is progressively replaced by auctioning in this period.

The legislative framework of the EU ETS for the next trading period (phase 4, 2021-2030) was revised to enable achieving the EU's 2030 emission reduction targets in line with the 2030 climate and energy policy framework and as part of the EU's contribution to the 2015 Paris Agreement. The revision focuses on:

- Strengthening the EU ETS as an investment driver by increasing the pace of annual reductions in allowances to 2.2% as of 2021;
- Reinforcing the Market Stability Reserve (the mechanism established by the EU in 2015 to reduce the surplus of emission allowances in the carbon market);
- Continuing the free allocation of allowances as a safeguard for the international competitiveness of industrial sectors at risk of carbon leakage;
- Helping industry and the power sector via several low-carbon funding mechanisms.

Manufacturing industry will continue to receive a share of free allowances also after 2020. Free allocation is carried out based on benchmarks of greenhouse gas (GHG) emissions performance. Installations that meet the benchmarks should receive all the allowances they need. Those that do not reach the benchmark values will receive fewer allowances than they need. These installations will therefore have to reduce their emissions, or buy additional allowances to cover their emissions.

A product benchmark is based on a value reflecting the average GHG emission performance of the 10% best performing installations in the EU ETS.

The benchmarks have been established for various products, discounting the technology, fuel used, or the size of an installation.

The EU ETS influences through the increase of electricity price also the industrial, domestic and commercial sectors. For example, a substitution of electricity intensive industrial products may be expected.

In the first two phases, the cap on allowances was set at national level through national allocation plans (NAPs). Phase one caps were set mainly on the basis of historic emissions data. The total allocation of EU ETS allowances exceeded demand and in 2007, the price of phase one allowances fell close to zero.

In the second period the cap was cut by 6.5% compared to the 2005 level. Due to the economic crisis that began in late 2008 there was a surplus of unused allowances again. The aviation sector was brought into the EU ETS on 1 January 2012 through legislation adopted in 2008.

Mitigation impact: Estimate of EU ETS impact on emissions on the demand side is a result of a simulation model based on energy prices (derived from fuel prices without and with CO_2 price) and cost curves of emission reducing measures. For the demand side, the calculation involves emissions reduction of projects realized in frame of transitional free allocations of emission permits. Main assumptions are that EU ETS directly influences about 41% of final energy consumption in industry, and indirectly about 75% heat consumers and 100% electricity consumers. Having in mind, that the State Energy Policy envisages elimination of most coal power plants and their replacement by nuclear power plants between 2030 and 2040, the gains from EU ETS are rather low. Tab. 1-2 shows drop of GHG emissions caused by energy savings and changes in use of individual energy carriers.

Tab. 1-2 Expected emissions reduction of EU ETS on the demand side

Emissions reduction [kt CO_2]	2015	2018	2020	2025	2030	2035
Households	98	74	319	535	892	1 194
Services	99	76	292	447	656	877
Industry	188	135	419	568	842	1 127
Total	**385**	**285**	**1 030**	**1 551**	**2 390**	**3 198**

Tab. 1-3 Expected emissions reduction of EU ETS due to investments within the transition period

Emissions reduction [kt CO_2]	2015	2018	2017	2018	2019
	90	177	1 442	163	2 360

Tab. 1-4 Total expected effect of EU ETS in terms of emissions reduction

Total emissions reduction [kt CO_2]	2015	2018	2020	2025	2030	2035
	475	553	2 740	3 424	6 624	7 432

Additional information: It is expected that the EU ETS policy together with the IED has forced emission polluters to not only phase-out or reconstruct (e.g., installation of new boilers) some less efficient and outdated facilities but also to switch from coal to cleaner alternatives like natural gas or biomass.

1.1.1.3. Air Protection Act

GHG affected: CO_2, CH_4, N_2O

Type of policy: Regulatory

Implementing entity: Ministry of Environment (Government)

Period of implementation: 2002 - 2040

Implemented in scenario: WEM

Sectors: 1. Energy; 2. Industrial processes and product use; 3. Agriculture**;** 5. Waste

Characteristics of PaM: The Act No. 201/2012 Coll. replaced Act No. 86/2002 Coll. transposes Directive 2015/2193/EU on the limitation of emissions of certain pollutants into the air from medium combustion plants, Directive 2001/80/EC on the limitation of emissions of certain pollutants into the air from large combustion plants, Directive 2010/75/EU on integrated pollution prevention and control, Directive 2015/1513/ on the promotion of the use of energy from renewable sources and provides the following significant changes:

a. Compensation measures

The current legislation will ensure that in areas with poor air quality a new pollution source won´t be put into operation, unless it demonstrates applicable measures to offset the new extra pollution. Compensation measures have investment and operational character.

b. Implementation of low emission zones

Municipalities and cities can set zones within their territories only for cars complying with the emission limits. However, they must provide an alternative route outside the zone of the same or higher class.

c. New parameters for domestic boilers

The new legislation also affects households. Small boilers (power output up to 300 kW) put on the market in the Czech Republic must have significantly lower emissions comparing to current situation. From 1st of September 2022 the law prohibits operation of boilers, which meet the first and second emission classes. The law also prohibits the burning of low-quality fuels.

Emission limits for small combustion plants up to 300 kW depend on the performance, dosage, type and calorific value of the fuel.

d. Inspection of households

The new law establishes a mandatory verification of emission sources and technical parameters of boilers with a thermal input between 10 and 300 kW, which is used for central water heating. These inspections will be carried out by persons authorized by the Ministry of Environment. In addition to the visual inspection, these entities can also advise the owner regarding the adjustment, cleaning and optimal use of a boiler.

e. Individual evaluation of large polluters

The new law also allows individual access to air polluters. Competent regional authorities can also decrease the activity of an emission source, which has a bad influence on the air quality in certain area.

f. Simple charges

The new law also significantly simplifies the payment of charges. The number of charged substances is reduced from 24 to 4. Charges are approximately 10 times higher in comparison to previous levels. From 2017, the charges continue to growth gradually up to 2022.

The Act also allows a reduction of charges in case that an operator reduces emissions beyond the minimum legal requirements.

Mitigation impact: This is a framework measure and its mitigation effect is accounted in other measures.

1.1.1.4. The Climate Protection Policy of the Czech Republic

GHG affected: CO_2, CH_4, N_2O, SF_6, NF_3

Implementing entity: Ministry of Environment (Government)

Period of implementation: 2017 – 2030

Implemented in scenario: WEM

Sectors: 1. Energy; 2. Industrial processes and product use; 3. Agriculture; 4. Land Use, Land-Use Change and Forestry; 5. Waste

Characteristics of PaM: The Policy defines GHG reduction targets for 2020 and 2030. It also includes indicative trajectories and objectives for 2040 and 2050. The Policy defines policies and measures for specific sectors on national level. Most of the identified policies and measures will be implemented by the time of the next planned Policy update in 2023.

The Government adopted the Climate Protection Policy of the Czech Republic in March 2017 (see Government Resolution No. 207/2017) replacing former National Programme to Abate the Climate Change Impacts in the Czech Republic. This Policy reflects significant recent developments at the EU, international and national level. The long-term perspective for gradual transition to low emission development until 2050 was included in such governmental document for the first time. The Strategic Impact Assessment of the Policy was carried out and completed with an affirmative statement in January 2017.

This Policy sets specific targets and measures for the particular sectors on national level in order to fulfill GHG reduction targets resulting from international agreements as well as EU legislation. This Policy should contribute to gradual transition to low emission development until 2050. The Policy further sets primary and indicative emission reduction targets, which should be reached in a cost-efficient manner. Measures are proposed in the following key areas: energy, final energy consumption, industry, transport, agriculture and forestry, waste, science, research and development, and voluntary tools.

Mitigation impact:

Primary emission reduction targets

- GHG reduction of 32 Mt CO_2 eq. compared to 2005 until 2020
- GHG reduction of 44 Mt CO_2 eq. compared to 2005 until 2030

Indicative emission reduction targets

- Indicative level towards 70 Mt CO_2 eq. of emitted GHG in 2040
- Indicative level towards 39 Mt CO_2 eq. of emitted GHG in 2050

Additional information: The Policy also outlines some economic aspects for the greenhouse gas reductions on the national level. The European structural and investment funds represent the main source of financing in the programming period of 2014 - 2020. Another key financial source is represented by the auction revenues generated by the EU ETS.

The Policy will be evaluated in 2021 and based on such evaluation the Policy will be updated by 2023.

1.2.Policies and Measures in Energy sector

1.2.1.1. Policies and Measures cross-cutting several categories/subcategories in Energy sector

Following chapter describes PaMs which have impact at least on two categories/subcategories under Energy sector.

1.2.1.2. Modernisation Fund

GHG affected: CO_2, CH_4

Type of policy: Economic

Implementing entity: State Environmental Fund

Period of implementation: 2021 - 2030

Implemented in scenario: WAM

Category: 1.A.1 Energy industries, 1.A.2 manufacturing Industries and construction, 1.A.3 Transport, 1.A.4 Other sectors

Characteristics of PaM: The Modernisation Fund is a dedicated funding programme to support 10 lower-income EU Member States in their transition to climate neutrality by helping to modernise their energy systems and improve energy efficiency. It was established by Article 10d of the EU ETS Directive. The Modernisation Fund is funded from revenues from the auctioning of 2% of the total allowances for 2021-30 under the EU ETS and additional allowances transferred to the Modernisation Fund by beneficiary Member States.

In early 2021, the Czech Government approved the programme document for the Modernisation Fund and first calls for project proposals will be open later in 2021. The Modernisation Fund was designed to be complementary to other national support programmes and operational programmes.

It is divided into 9 specific support programmes aimed at the following areas:

- Heating Sector – change of fuel, reconstruction of networks
- New non-combustion Renewable Energy Sources for electricity production
- Improving energy efficiency and reducing emissions in industrial EU ETS installations
- Improving energy efficiency in industry outside the scope of EU ETS
- Modernisation of transport in the business sector
- Modernisation of public transport
- Improving energy efficiency in public buildings and infrastructure
- Support of community energy systems
- Modernisation of public lighting systems

It is expected that the total financial allocation for Modernisation Fund will be more than 5 billion EUR. However, it depends on the price of EU ETS allowance. 30% of the total auctioning revenues should be allocated to the heating sector and 40 % for new renewable energy sources (RES) installations for electricity production.

Mitigation Impact: It is expected that the activities funded by the Modernisation Fund will achieve 10.3 PJ reduction in final energy consumption and will support more than 3000 MWe of newly installed RES capacity. The total mitigation impact is expected to reach 17,500 kt CO_2 eq. by 2030.

1.2.1.3. Eco-design

GHG affected: CO_2

Type of policy: Regulatory

Implementing entity: Ministry of Industry and Trade (Government)

Period of implementation: 2007 - 2035

Implemented in scenario: WEM

Categories: 1.A. Fuel combustion

Characteristics of PaM: Eco-design designs and develops a product with the emphasis on a minimum negative impact on the environment (incl. energy consumption). A set of requirements must be met before products enter the market ensuring energy efficiency for manufacture, usage and disposal of products.

The Czech legislation has transposed the EU directives 2005/32/EC and 2009/125/EC (recast) to establish a framework for the setting of eco-design requirements for products energy using energy.

The eco-design directives have been implemented into the Czech legislation by the Energy Management Act No. 406/2000 Coll. and by its amendment 393/2007 Coll. Under the EU directive a set of regulations requires a minimal energy efficiency of new electric appliances. Product categories included in the Regulation and reflected in the projections are:

- Air conditioners and comfort fans;
- Air heating and cooling products;
- Circulators;
- Computers;
- Domestic cooking appliances;
- Electric motors;
- External power supplies;
- Household dishwashers;
- Household washing machines;
- Industrial fans;
- Lighting products in the domestic and tertiary sectors;
- Local space heaters;
- Heaters and water heaters;
- Power transformers;
- Professional refrigerated storage cabinets;
- Refrigerators and freezers;
- Simple set-top boxes;
- Standby and off mode electric power consumption of household and office equipment, and network standby;
- Televisions;
- Vacuum cleaners;
- Ventilation units;
- Water pumps.

Mitigation impact: Application of the eco-design leads to electricity savings. The annual energy savings were calculated in the NEEAP III (MIT, 2014) amounting to 1230 TJ/year by 2020.

1.2.1.4. Energy Management Act

GHG affected: CO_2

Type of policy: Regulatory

Implementing entity: Ministry of Industry and Trade (Government)

Period of implementation: 2000 – 2035

Implemented in scenario: WEM

Categories: 1.A. Fuel combustion

Characteristics of PaM: The Act deals with specific measures leading to energy savings such as efficiency of energy production, energy intensity of buildings, building energy performance certificate, energy labels, energy audit and eco-design. The Act transposes Directive 2010/31/EU on the energy performance of buildings, Directive 2010/30/EU on the indication by labelling and standard product information of the consumption of energy and other resources by energy-related products, Directive 2009/125/EC establishing a framework for the eco - design requirements for energy-related products, Directive 2009/28/EC on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC. The mitigation effects of these measures included in the Act were calculated separately.

This Act, which has been amended several times since 2000, stipulates e.g.:

- Measures for increasing the economic use of energy and the obligations of natural and legal persons in energy management;
- Rules for the drafting of the National Energy Policy, Territorial Energy Policies, for the Promotion of Energy Conservation and the Use of Renewable Sources of Energy;
- Requirements on eco-design of energy-using products;
- Energy labels;
- Energy performance of buildings;
- Energy audits and auditors.

Mitigation impact: This is a framework measure and its mitigation effect is accounted in other measures.

1.2.1.5. National Energy Efficiency Action Plan (NEEAP)

GHG affected: CO_2

Type of policy: Economic, Fiscal, Information, Voluntary

Implementing entity: Ministry of Industry and Trade (Government)

Period of implementation: 2008 - 2020

Implemented in scenario: WEM

Sector: 1. Energy

Characteristics of PaM: The Directive establishes a set of binding measures to reach the EU 20% energy efficiency target by 2020. Under the Directive, all EU countries are required to use energy more efficiently at all stages of the energy chain, from production to final consumption.

National measures must ensure major energy savings for consumers and industry, for example:

- Energy distributors or retail energy sales companies have to achieve 1.5% energy savings per year through the implementation of energy efficiency measures;

- EU countries can opt to achieve the same level of savings through other means, such as improving the efficiency of heating systems, installing double glazed windows or insulating roofs;
- The public sector should purchase energy efficient buildings, products and services;
- Governments in EU countries must carry out energy efficient renovations on at least 3% (by floor area) of the buildings they own and occupy on annual basis;
- Consumers should be empowered to manage better energy consumption, incl. easy and free access to data on consumption through individual measuring;
- National incentives for small and medium enterprises (SME) to undergo energy audits;
- Large companies audit their energy consumption and identify ways to reduce it;
- Monitoring efficiency levels in new energy generation capacities.

National Energy Efficiency Action Plans (NEEAPs) set out estimated energy consumption, planned energy efficiency measures, and the improvements a country expect to achieve. Under the Energy Efficiency Directive, EU countries must draw up these plans every three years.

The indicative national target defined in Article 3 of Directive 2012/27/EU is a framework, non-binding target. It was set for the Czech Republic in 2015 at 50.67 PJ of new final energy savings by 2020.

Article 7 of the Directive establishes a binding end-use energy savings target by 2020 equivalent to achieving new annual savings of 1.5% of the annual energy sales to end customers (see Tab. 1-5).

Tab. 1-5 Calculation of the binding savings target stipulated in the Directive, Article 7 (2) (MIT, 2017)

Year	Savings [PJ]
2018	48.66
2019	58.40
2020	68.13

Mitigation impact: This is a framework measure and its mitigation effect is accounted in other measures.

1.2.1.6. State programme on promotion of energy savings (EFEKT 2)

GHG affected: CO_2

Type of policy: Economic (subsidies), Education, Information, Research

Implementing entity: Ministry of Industry and Trade (Government)

Period of implementation: 2017 – 2035

Implemented in scenario: WEM

Sectors: 1.A. Fuel combustion

Characteristics of PaM: The programme financially supports the increase of energy efficiency through awareness raising and educational activities, energy consultancy centres and expert training. It is a crosscutting programme and the target sectors are the state administration and local governments, private sector, households and NGO's. This programme also supports the following activities: (a) measures to reduce the energy intensity of public street lighting; (b) reconstruction of a heating system and the heat generation in buildings; (c) publications, guides and informative materials about the 1. Energy sector; introduction of an energy management system; preparation of energy-saving projects financed using the Engineering, Procurement and Construction (EPC) method.

Mitigation impact: The expected programme energy savings shows the following table.

Tab. 1-6 Expected energy savings of programme EFEKT 2

Energy savings [TJ]	2015	2020	2025	2030	2035	2040	2045	2050
	0	778	778	778	778	778	778	778

Using emissions factors (EF) taking into account changes in the fuel mix in power and heat generation we obtain the following reductions in GHG emissions in the final energy consumption.

Tab. 1-7 Expected emissions reduction of programme EFEKT 2

Emissions reduction [kt CO_2 eq.]	2015	2020	2025	2030	2035	2040	2045	2050
	0.00	57.05	52.58	50.46	46.35	39.43	38.80	37.87

Additional information: The budget of the program is estimated to be 0.7 bill. CZK (approx. 27 mill. €). for the period 2017 – 2020 (MIT, 2017). The implementation and financing of the State Program is in compliance with Act No. 406/2000 Coll., on budget rules. The program contributes to reach the energy target according to Directive 2012/27/EU on energy efficiency.

1.2.1.7. Operational Programme Enterprise and Innovation for Competitiveness

GHG affected: CO_2

Type of policy: Economic

Implementing entity: Ministry of Industry and Trade (Government)

Period of implementation: 2014 – 2020

Implemented in scenario: WEM

Categories: 1.A.2. Manufacturing industries and construction; 1.A.4.a. Commercial/Institutional; 1.A.4.c. Agriculture/Forestry/Fishing

Characteristics of PaM: The Programme supports knowledge and innovation in order to achieve sustainable and competitive economy. The programme is financed by the European Regional Development Fund (ERDF) to support enterprises, mostly SMEs. Four priority axes are the main content of the programme from which priority axis 3 “Improving energy efficiency and support for new low-carbon technologies” is aimed at reducing GHG emissions. The thematic focus of priority axis 3 is the development of smart energy distribution, transmission and storage systems that include also integration of distributed generation from renewable sources. The priority axis 3 comprises the following specific objectives:

- Increasing share of energy from renewable sources in gross final consumption
- Energy savings in the business sector
- Increasing the application of smart grids in distribution networks
- Low-carbon technology transition and use of secondary raw materials
- Co-generation of combined heat and power for heat supply
- Strengthening the energy security of the transmission system

The indicated specific objectives comprise numerous activities among which are the following:

- Installation of a remote co-generation unit using biogas from biogas plant
- Construction and reconstruction of heat sources and combined production of electricity and heat from biomass and subsequent heat extraction
- Use of waste energy in production processes
- Installation of cogeneration units for internal consumption of the enterprise

- Installation of electricity accumulation units
- Implementation of measures to improve the energy performance of buildings in the business sector (replacement and renovation of windows and doors, building insulation, installation of waste heat recuperation and air-conditioning, etc.)
- Support for extra costs for achieving the standard of a nearly zero energy consumption of existing and new constructions of business buildings
- Introduction of innovative low-carbon technologies in the fields of energy production, buildings, transport, processing and use of secondary raw materials
- Installation of renewable energy sources for internal industrial consumption
- Construction and reconstruction of transmission networks and transformer stations

Mitigation impact: The expected programme energy savings is shown in Tab 1-10 below.

Tab. 1-8 Expected energy savings of the programme Operational Programme Enterprise and Innovation for Competitiveness

Energy savings [TJ]	2015	2020	2025	2030	2035	2040	2045	2050
	0	10 640	13 030	13 030	13 030	13 030	13 030	13 030

Using emission factors, which respect changes in the fuel mix in power and heat generation and in the final energy consumption, we obtain the following reductions in greenhouse gases emissions.

Tab. 1-9 Expected emissions reduction resulting from energy savings of the programme Operational Programme Enterprise and Innovation for Competitiveness

Emissions reduction [kt CO_2 eq.]	2015	2020	2025	2030	2035	2040	2045	2050
	0.00	799.37	1 160.04	1 122.63	1 045.09	893.72	878.81	857.76

Besides energy savings, the programme supports use of RES as well. The programme document envisages installing 70 MW in RES sources that will lead to drop in GHG emissions of 300 kt by 2023. Assuming electricity to heat ratio equal to 2:1 and with respect to development of fuel mix used for electricity and heat generation, the resulting mitigation impact will be:

Tab. 1-10 Expected energy production from RES and corresponding emissions reduction of the programme Operational Programme Enterprise and Innovation for Competitiveness

	2015	2020	2025	2030	2035	2040	2045	2050
Electricity generation from RES [TJ]	0.0	427.4	1 424.6	1 424.6	1 424.6	1 424.6	1 424.6	1 424.6
Heat generation from RES [TJ]	0.0	213.7	712.3	712.3	712.3	712.3	712.3	712.3
GHG emissions reduction [kt CO_2 eq.]	0.0	99.4	280.2	258.0	216.2	163.9	163.9	163.9

Additional information: The total program budget for energy savings and of RES support is 19 bill. CZK (approx. 730 mill. €).

1.2.1.8. Implementation of the Directive on the energy performance of building (2010/31/EU)

GHG affected: CO_2

Type of policy: Regulatory

Implementing entity: Ministry of Industry and Trade (Government)

Period of implementation: 2007 – 2035

Implemented in scenario: WEM

Categories: 1.A.1. Energy industries; 1.A.2. Manufacturing industries and construction; 1.A.4. Other sectors

Characteristics of PaM: The measure stipulates minimum requirements as regards the energy performance of new and existing buildings, requires the certification of their energy performance and the regular inspection of boilers and air conditioning systems in buildings. It includes Czech legislation and programs for reduction of energy consumption and increased use of RES in buildings.

The Directive is transposed by the Act No. 318/2012 Coll., on energy management. The directive defines new administrative tools to reduce energy consumption of buildings. It defines a building with zero energy consumption. It tightens requirements for energy building performance with the aim to reduce energy consumption and emission of GHG by 20% and increase the share of RES.

Energy building performance is defined as calculated/measured typical energy consumption which also includes energy used for heating, ventilation, cooling, air-conditioning, hot water and lighting.

Not only energy performance, but also optimal economic costs are emphasized. In 2011, the European Commission (EC) issued a methodological framework for the calculation of optimal cost levels for minimal requirements on energy building performance.

Until 2020, all new buildings shall be buildings with almost zero energy consumption. From 2019 all new buildings used or owned by public administration shall be buildings with almost zero energy consumption. According to the Directive "a building with almost zero energy consumption" is a building with very low energy performance. The energy performance shall be estimated in compliance with the Directive methodology. The low consumption should be mainly covered by RES.

The energy performance certificates according to the Recast directive contain new information, e.g. besides energy performance and reference values (minimal requirements for energy performance) also recommendations for decreasing of energy performance taking into account cost optimization. Contact to other information sources, especially regarding cost efficiency shall be included in the certificate as well.

Mitigation impact: Emission reduction effects are included in other PaMs (e.g.: New Green savings programme, Operational Programme Environment, Integrated Regional Operating Programme, etc.).

1.2.1.9. ENERG Programme

GHG affected: CO_2

Type of policy: Economic

Implementing entity: Ministry of Industry and Trade (Government)

Period of implementation: 2017-2033 **Implemented in scenario:** WEM

Categories: 1.A.2. Manufacturing industries and construction; 1.A.4. Other sectors

Characteristics of PaM: This programme of the Ministry of Industry and Trade is focused on the provision of soft loans for the implementation of projects improving energy performance. The administrator of the financial instrument is the Czech-Moravian Guarantee and Development Bank.

Mitigation impact: The expected programme energy savings are shown in Tab. 1-15 below.

Tab. 1-11 Expected energy savings of the Energy Programme

	2015	2020	2025	2030	2035	2040	2045	2050
Energy savings [TJ]	0	40	40	40	40	40	40	40

Using emission factors, which respect changes in the fuel mix in power and heat generation and in the final energy consumption, we obtain the following reductions in greenhouse gases emissions.

Tab. 1-12 Expected emissions reduction related to energy savings of the Energy programme

Emissions reduction [kt CO_2 eq.]	2015	2020	2025	2030	2035	2040	2045	2050
	0.00	4.05	3.67	3.49	3.20	2.70	2.66	2.59

Additional information: The expected annual budget for the period 2014 – 2020 is estimated to be about 0.1 bill. CZK (3.9 mill. €) (MIT, 2017)

1.2.1.10. Operational Programme Prague Growth Pole

GHG affected: CO_2

Type of policy: economic

Implementing entity: City of Prague

Period of implementation: 2014 – 2020

Implemented in scenario: WEM

Categories: 1.A.3. Transport; 1.A.4.a. Commercial/Institutional

Characteristics of PaM: The operational programme under the auspices of the City of Prague focuses on support for improving the energy performance of buildings and the technical equipment used to ensure the operation of municipal public and road transport, implementation of pilot projects to convert energy intensive municipal buildings into nearly-zero energy buildings.

Mitigation impact: The expected programme energy savings are shown in Tab. 1-17 below.

Tab. 1-13 Expected energy savings of the Operational Programme Prague Growth Pole

Energy savings [TJ]	2015	2020	2025	2030	2035	2040	2045	2050
	0	34	36	36	36	36	36	36

Using EFs, which respect changes in the fuel mix in power and heat generation and in the final energy consumption, we obtain the following reductions in GHG emissions.

Tab. 1-14 Expected emissions reduction related to energy savings of the Operational Programme Prague Growth Pole

Emissions reduction [kt CO_2 eq.]	2015	2020	2025	2030	2035	2040	2045	2050
	0.00	3.56	3.51	3.20	2.83	2.30	2.26	2.21

Additional information: The expected annual budget for the period 2014 – 2020 is estimated to be about 1.9 bill. CZK (74.5 mill. €) (MIT, 2017).

1.2.1.11. Energy efficiency measures in industry sector in the period 2021-2030

GHG affected: CO_2

Type of policy: economic

Implementing entity: Ministry of Industry and trade

Period of implementation: 2021 – 2030)

Implemented in scenario: WAM

Category: 1.A.1. Energy industries, 1.A.2. Manufacturing industries and construction

Characteristics of PaM: The specific list of measures is not known yet, however Following measures will be implemented.

- Construction and reconstruction of heat sources
- Use of waste energy in production processes
- Installation of cogeneration units
- Improvement of the energy performance of buildings (replacement and renovation of windows and doors, building insulation, installation of heat recuperation)

Mitigation impact: The expected energy savings are shown in Tab. 1-19 below.

Tab. 1-1915 Expected energy savings of the energy efficiency measures in industry sector

	2015	2020	2025	2030	2035	2040	2045	2050
Energy savings [TJ]	0	0	10 500	21 000	21 000	21 000	21 000	21 000

Using EFs, which respect changes in the fuel mix in power and heat generation and in the final energy consumption, we obtain the following reductions in GHG emissions (Tab. 1-20).

Tab. 1-2016 Expected emissions reduction related to energy efficiency measures in industry sector

	2015	2020	2025	2030	2035	2040	2045	2050
Emissions reduction [kt CO_2 eq.]	0	0	934.77	1 809.27	1 684.30	1 440.35	1 440.35	1 440.35

1.2.1.12. Soft energy efficiency measures in the period 2021-2030

GHG affected: CO_2

Type of policy: information, education

Implementing entity: Ministry of Industry and trade

Period of implementation: 2021 – 2030

Implemented in scenario: WAM

Category: 1.A.1. Energy industries, 1.A.2. Manufacturing industries and construction, 1.A.4.a. Commercial/Institutional; 1.A.4.b. Residential

Characteristics of PaM: Following measures will be implemented:

- Energy-saving advices
- Marketing and awareness campaigns
- Best practise examples
- Public information meetings, exhibitions

Mitigation impact: The expected energy savings shows the following table.

Tab. 1-2117 Expected energy savings of the soft energy efficiency measures

	2015	2020	2025	2030	2035	2040	2045	2050
Energy savings [TJ]	0	0	7 500	15 000	15 000	15 000	15 000	15 000

Using EFs, which respect changes in the fuel mix in power and heat generation and in the final energy consumption, we obtain the following reductions in GHG emissions.

Tab. 1-2218 Expected emissions reduction related to soft energy efficiency measures

	2015	2020	2025	2030	2035	2040	2045	2050
Emissions reduction [kt CO_2 eq.]	0	0	506.75	972.64	893.41	759.93	759.93	759.93

1.2.1.13. Policies and measures in 1.A.1 Energy industries

1.2.1.14. Energy Act

GHG affected: CO_2

Type of policy: Regulatory

Implementing entity: Ministry of Industry and Trade (Government)

Period of implementation: 2000 – 2035

Implemented in scenario: WEM

Sectors: 1.A.1. Energy industries

Characteristics of PaM: The Act transposes relevant EU legislation[1], includes directly applicable EU legislation[2] and sets conditions for business, for public administration and for energy regulation (electricity, gas and heat).

Mitigation impact: This is a framework measure and its mitigation effect is accounted in other measures.

1.2.1.15. National Renewable Energy Action Plan (NREAP)

GHG affected: CO_2

Type of policy: Economic, Fiscal

Implementing entity: Ministry of Industry and Trade (Government)

Period of implementation: 2010 – 2020

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1 *Directive 2009/72/EC of the European Parliament and of the Council concerning common rules for the internal market in electricity and repealing Directive 2003/54/EC.*

Directive 2009/73/EC of the European Parliament and of the Council concerning common rules for the internal market in natural gas and repealing Directive 2003/55/EC.

Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC

Directive 2005/89/EC of the European Parliament and of the Council concerning measures to safeguard security of electricity supply and infrastructure investment.

Directive 2011/83/EU of the European Parliament and of the Council on consumer rights, amending Council Directive 93/13/EEC and Directive 1999/44/EC of the European Parliament and of the Council and repealing Council Directive 85/577/EEC and Directive 97/7/EC

2 *Regulation (EC) No 715/2009 of the European Parliament and of the Council of 13 July 2009 on conditions for access to the natural gas transmission network.*

Regulation (EC) No 714/2009 of the European Parliament and of the Council of 13 July 2009 on conditions for access to the network for cross-border exchanges in electricity.

Regulation (EC) No 713/2009 of the European Parliament and of the Council of 13 July 2009 establishing an Agency for the Cooperation of Energy Regulators.

Council Regulation No 617/2010 of 24 June 2010 concerning the notification to the Commission of investment projects in energy infrastructure within the European Union.

Regulation (EU) No 994/2010 of the European Parliament and of the Council of 20 October 2010 concerning measures to safeguard security of gas supply.

Implemented in scenario: WEM

Sectors: 1.A.1. Energy industries

Characteristics of PaM: The plan implements Renewable Energy (RE) Directive 2009/28 which, requires that the EU Member States will cover a specified percentage of final energy demand by renewable energy in 2020. The Czech Republic is committed to achieve 13% share of RE in 2020, while the total EU target is 20%.

The main aim of the RE Directive is to establish a common framework for the promotion of energy from renewable energy sources and the principal requirements are:

- Mandatory national overall targets and measures for the use of energy from renewable sources
- National renewable energy action plans
- Calculation of the share of energy from renewable sources
- Statistical transfers between Member States
- Joint projects between Member States
- Effects of joint projects between Member States
- Joint projects between Member States and third countries
- Effects of joint projects between Member States and third countries
- Joint support schemes, etc.

The Directive requires each Member State to submit a National Renewable Energy Action Plan (NREAP) describing how it plans to achieve its 2020 target. The Czech NREAP was submitted to EC in July 2010 and subsequently updated in July 2012 and in December 2015 (MIT, 2015). The main renewable energy sources in the Czech Republic are biomass, followed by biofuels for transportation, biogas, hydropower and photovoltaic.

Mitigation impact: The plan establishes a framework for fulfilling the binding targets according to two following tables.

Tab. 1-23 Share of RES on final consumption of energy in 2005 and the target according to Directive 2009/28/EC

	2005	2020
RES consumption [PJ]	76.2	161.7
The share of RES [%]	6.1	13

Tab. 1-194 Share of RES on final consumption of energy according to NREAP, 2015 (MIT, 2015)

	2005	2020
RES consumption [PJ]	76.2	172.9
The share of RES [%]	6.1	15.3

The impacts of the plan are reported under other measures supporting introduction of RES.

Additional information: The National Renewable Energy Action Plan is evaluated every two years by Ministry of Industry and Trade. The results are reported to the Czech Government and the European Commission.

1.2.1.16. Preferential feed-in tariffs for electricity produced from renewable energy sources

GHG affected: CO_2

Type of policy: Economic

Implementing entity: Energy Regulatory Authority (Government)

Period of implementation: 2004 - 2035

Implemented in scenario: WEM

Category: 1.A.1.a. Public electricity and heat production

Characteristics of PaM: Preferential feed-in tariffs (Act 165/2012 Coll.), together with obligation of distribution companies to connect sources using renewables and to purchase the produced electricity, serve as a main tool for the promotion of RES in the Czech Republic.

Act 165/2012 Coll. transposes Directive 2009/28/EC on the promotion of electricity produced from renewable energy sources in the internal electricity market.

This measure guarantees preferential feed-in tariffs or a green bonus for electricity produced in power plants from renewable energy for a plant life (20 – 30 years). The tariffs are calculated according to the investment costs divided into 15 years. The advantageous tariff is paid to the suppliers by the distribution companies and is fully reflected in the price of electricity sold by those distribution companies. Electricity from biomass, but also photovoltaic-, wind- and hydropower plants are financially supported. Disproportionately high feed-in tariffs caused an unforeseen solar boom in 2010. Therefore, a new law has been approved which significantly decreases these tariffs (especially for photovoltaic and wind electricity). Moreover, a special tax of 26% for the solar electricity was introduced for the period 2011 – 2013.

Since 2014 power plants using RES (except small hydro power plants up to capacity of 10 MWe) were not supported anymore. According to the Act 165/2012 Coll. on supported energy sources mainly co-generation power plants with the total efficiency above 75% will receive financial support in the future. By these plants not only electricity, but also heat production will be subsidized.

According to National Renewable Energy Action Plan 2020 the target of 13 % share of renewable energy in electricity production will be met.

Mitigation impact: We attributed 50 % of new installation of biomass and biogas CHPs and 100 % of new installations in solar, wind and small hydro power plants to this measure. The emission reduction was calculated from expected electricity production and average system emission coefficient for electricity production.

Tab. 1-25 Emissions reduction expected from introduction of preferential feed-in tariffs for electricity produced from RES

	2015	2020	2025	2030	2035	2040	2045	2050
Emissions reduction [kt CO_2 eq.]	3 229	3 242	3 873	4 047	3 610	3 191	3140	3065

1.2.1.17. Policies and measures in 1.A.3 Transport

1.2.1.18. EU regulation on CO_2 from light-commercial vehicles (vans)

GHG affected: CO_2

Type of policy: Information

Implementing entity: Ministry of Transport (Government)

Period of implementation: 2000 - 2035

Implemented in scenario: WEM

Category: 1.A.3 Transport

Characteristics of PaM: As part of strategy to cut CO_2 emissions from light-duty vehicles, the European Commission adopted the Directive on the Promotion of Clean and Energy Efficient Road Transport Vehicles 2009/33/EC.

Regulation No 253/2014/EU amending Regulation No 510/2011/EU defines the modalities for reaching the 2020 target to reduce CO_2 emissions from new light commercial vehicles. The Regulation builds on a well-established process of measuring and monitoring the CO2 emissions of vehicles in accordance with Decision No 1753/2000/EC.

Mitigation Impact: The main objective of the vans Regulation is to cut CO_2 emissions from vans to 175 g CO_2/km by 2017 and to reach 147g CO_2/km by 2020. These cuts represent reductions of 14% and 28% respectively compared with the 2007 average of 203 g/km. The CO_2 emission reduction has been calculated by applying the target averaged emission factor (147 g CO_2/km) for all vans in future years where projection has been calculated. The total emission reduction of this measure is 331.64 kt. CO_2 eq. in 2035 year.

Additional information: The 2017 target was phased in 2014 and 2016 when an average of 70% and 80%, respectively, of each manufacturer's newly registered vans must comply with the limit value curve (heavier vans are allowed higher emissions than lighter vans). If the average CO_2 emissions of a manufacturer's fleet exceed its limit value in any year from 2014, the manufacturer has to pay an excess emissions premium for each van registered. The legislation affects vans, which account for around 12% of the market for light-duty vehicles. This includes vehicles used to carry goods weighing up to 3.5 t (vans and car-derived vans, known as "N1") and which weigh less than 2610 kg when empty.

1.2.1.19. EU regulation on CO_2 from passenger cars

GHG affected: CO_2

Type of policy: Regulatory

Implementing entity: Ministry of Transport, State Fund of Transport Infrastructure

Period of implementation: 2000 - 2035

Implemented in scenario: WEM

Category: 1.A.3 Transport

Characteristics of PaM: The European Commission also issued Regulation No 333/2014/EU amending Regulation No 443/2009/EC Regulation about the emission limits of CO_2 for new passenger cars. The Regulation builds on a well-established process of measuring and monitoring the CO_2 emissions of vehicles in accordance with Decision No 1753/2000/EC.

Mitigation Impact: Car manufacturers are obliged to ensure that average emissions level of a new car will be not more than 130 grams of CO_2/km by 2015 and 95 grams of CO_2/km in 2021. Regarding fuel consumption, these targets for 2015 roughly correspond to 5.6 liters of gasoline per 100 kilometers, or 4.9 liters of diesel per 100 km. Aim for the year 2021, then 4.1 liters per 100 kilometers (for petrol) and 3.6 liters per 100 kilometers (for diesel). The CO_2 emission reduction has been calculated by applying the target averaged emission factor (95 g/km) for all passenger cars in 2021 – 2040 years. The total emission reduction of this measure is 2452 kt CO_2 eq. in 2035 year. Such a big reduction is calculated due to big difference between target 95 g/km of CO_2 and present CO_2 implied emission factors (derived from COPERT), which are in the range between 160-230 g/km for passenger cars, depending on a car category.

1.2.1.20. Support of biofuels

GHG affected: CO_2

Type of policy: Regulatory

Implementing entity: Ministry of Industry and Trade, Ministry of Transport (Government)

Period of implementation: 2000 - 2030

Implemented in scenario: WEM

Category: 1.A.3 Transport

Characteristics of PaM: The quality of fuels used in transport is regulated by Directive of the European Parliament and of the Council 2009/30/EC amending Directive 98/70/EC.

Mitigation Impact: The directive requires that the emission intensity of transport fuels fell to 10% by 31 December 2020, at least 6% compared to the average emission levels. Directive 2009/28/EC was transposed by the Act on Air Protection 201/2012 Coll., which sets the minimal shares of biofuels in gasoline and diesel in accordance with EU directive. The Government Decree 351/2012 Coll. sets sustainability criteria of biofuels. The Law on Consumption Tax 453/2016 Coll. levies biofuels with a lower tax rate. The baseline shall be based on the EU average level life cycle GHG emissions per unit of energy from fossil fuel products in 2010. Reducing greenhouse gas emissions is likely to be achieved by harnessing biofuels and fuels with lower carbon content (e.g., natural gas).

The directive also sets rules for the sustainable use of biofuels. Greenhouse gas emissions from biofuels must be at least 35% lower than a fuel they replace. Since 2017, this figure rises to 50% and from 2018 to 60% for biofuels produced in facilities that started production on January 1, 2017 or later.

The mitigation impact of biofuel was calculated with a help of modification of emission factors per a unit of energy. The resulted emission factor is here a weighted average of emission factors of fossil part and bio part, where weights correspond to percentage of these components blending and to plans to increase of bio components blending to petrol and diesel. The total emission reduction of this measure is 188 kt CO_2 eq. in 2035 year.

1.2.1.21. Support of public transport and modal shift from road transport

GHG affected: CO_2

Type of policy: Regulatory

Implementing entity: In total 14 regional authorities (the Czech Republic has 14 regions, incl. the capital Prague, and each region makes an effort to develop integrated public transport systems ("Integrovaný dopravní systém"- IDS), in regions, such as Southern and Northern Moravia, Olomouc, Central Bohemia) these systems already exist, in other regions are being prepared.

Period of implementation: There is no uniform period for all 14 regions. Each region has a development plan of its own. The plans are partly coordinated by the Ministry for Regional Development.

Implemented in scenario: WEM

Characteristics of PaM:

Increasing the attractiveness of public transport:

a) Introduction of the integrated public transport system (IDS)

The IDS provides public transport in a certain area via individual carriers in the rail transport and/or in other type of transport. The individual carriers and types of transport do not compete within this IDS system. On the contrary, they try to cooperate in order to gain new customers among users of passenger cars. The unified rules for IDS operation are not given and they differ from case to case but it is always a voluntary agreement of the carriers. Usually, establishment of this type involves enforcement of the unified pricing policy (one travel record enables us to travel in the whole network with various carriers), mutual interlacing of the railway timetables of the integrated carriers and establishing new connecting links, elimination of the overlapping lines of more carriers and set-up of a tact railway timetable (the connections are going at regular intervals). The IDS systems in Prague, South Moravia and Ostrava city belong to the most efficient ones in the Czech Republic.

However, this measure is valid on urban and regional level and that is why it is impossible to quantify its emission reduction.

b) Increasing of passengers' comfort

In order to increase the comfort during the travelling, modern low-ground vehicles enabling easier getting on and getting out for the passengers are put in operation and are also suitable for the transport of disabled people and mothers with prams. The necessary standard in the urban public transport is quality information equipment for the passengers. For easier transfers the construction or modernization of the interchange terminals with introducing the edge-edge transfers (linked connections are setting off from various sides of one platform so that the passengers do not have to go to other platforms through underpasses, overpasses, or even directly across the road in a complicated way) and sufficient maintenance in terms of travel culture. For example, air-conditioning, cleanness and design of the internal environment etc. belong to other elements increasing the travel comfort of public transport.

Due to the character of this measure, it is also impossible to determinate its contribution to GHG emission reduction.

c) Preference of public transport vehicles

The speed of public transport vehicles in cities is mainly decreased due to cars. It leads to delays of urban public transport. To increase the attractiveness of public transport, extra lanes for buses and trolleybuses in exposed places and the preference of the urban public transport in the light controlled intersections are supported. Also, this measure is on urban level.

d) Introduction of "Park and Ride" system

There is the effort in the Czech Republic to improve multi modal passenger transport by "Park and Ride" (P&R) In Prague, this system is now be combined with increasing rates of parking fees in the localities which have to be calmed down (so called "blue zones"). However, efficient implementation requires Park and Ride with bigger capacity, e.g., parking houses with several floors, in the outer part of a city. Although the parking sites for Park and Ride are well situated and marked, this measure is not much successful until now, due to the lack of their capacity

Systems of combined freight transport:

Not only passenger transport but also freight transport can be realized in a multi-modal manner. In terms of mitigation of the effects on human health the goods should be transported by rail as far as possible. Water transport is considered to be used for "ecological" transport as well but this is questionable regarding the negative effects on water ecosystems. Road haulage is in this point of view considered to be the worst. However, rail transport is not able to provide all transport of the goods to the destination - meaning "from doors to doors". Therefore, no transfer of the whole haulage from the road to the railway is possible.

However, a part of transported work of selected commodities is possible to be transferred by railway with help of the construction of logistic centers in important railway stations. Places for storage of the goods should be constructed there because goods are sent from there via freight trucks to target destinations. This option of freight combination should be then offered to truck transport operators who are interested in these services mainly in transport to abroad. Locations for logistics centers must be directly connected with the main railway lines. Truck arrival routes should be kept outside of populated areas. The equipment of the station with the work-siding premises is beneficial. The construction of logistic centers could be one of the ways to revitalize the unused areas which are called „brownfields" (they tend to be trailed; there are storage and loading facilities, etc.). Each proposed solution of the logistic centers should be verified by the transport model of the freight.

The support of railway transport shall be realized through investment programs for improvement of infrastructure, increasing of speed, promotion of intermodal (container) transport, construction of transship points and of logistic centers. The aim of the measure is to shift 30% of long distanced freight transport from roads to railways (in trips over 300 km).

Mitigation Impact: The emissions reduction of this measure was calculated by recalculation of activity data – subtraction of long freight trips (expressed in vehicle kilometers) from road transport and its addition to electrified railways with no exhaust emissions. The total emission reduction of this measure is 202.1 kt. CO2 eq. in 2035 year.

1.2.1.22. Operational Program Transport

GHG affected: CO_2

Type of policy: Economic

Implementing entity: State Fund of Transport Infrastructure

Period of implementation: 2007 - 2020

Implemented in scenario: WEM

Characteristics of PaM: The program provides support for construction, upgrading and development of the Trans-European Transport Networks (TEN-T) and regional rail transport networks. The Operational Program Transport implements transport strategy and other transport aspects of the National Development Plan. It focuses on modernization of railway and road networks. The main program indicators include a reduction of the accident rate, an increase of the transport capacity, time-saving and GHG emission reduction.

Basic overview of priority axes of the program:

- Priority Axis 1 – Upgrading the TEN-T
- Priority Axis 2 – Construction and modernization of the road network TEN-T
- Priority Axis 3 – Modernization of the railway network outside TEN-T
- Priority Axis 4 – Upgrading of roads outside TEN-T
- Priority 5 – Modernization and Development of the Prague Underground and systems of management of road transport in the City of Prague
- Priority 6 – Support of Multimodal Freight Transport and Development IWT
- Priority 7 – Technical Assistance

Mitigation Impact: The annual CO_2 emission drop was calculated from average emission coefficients of transport and annual energy savings estimated to 3 016 TJ/year from 2020 (MIT, 2015).

Additional information: The total allocation of the program was 5.8 bill. EUR for the period 2007-2013. The same amount is assumed for the period 2014 – 2020.

1.2.1.23. National Strategy of Cycling Transport Development

GHG affected: CO_2

Type of policy: Economic

Implementing entity: State Fund of Transport Infrastructure

Period of implementation: 2015 - 2020

Implemented in scenario: WEM

Category: 1.A.3 Transport

Characteristics of PaM: The measure supports the construction of cycling infrastructure. It is financed mainly from the State Transport Infrastructure Fund, which supports the following activities (see also: www.cyklostrategie.cz):

- Construction and maintenance of cycling infrastructure
- Connection to public transport
- The use of existing roads for the needs of cyclists
- Construction and reconstruction of cycling infrastructure (e.g., cycle lanes, bicycle underpasses)

The program is focused on the construction and maintenance of cycling paths. Cycling can partly replace vehicular traffic in urban and suburban areas and thus lead to energy and emission savings.

Additional information: The annual energy savings were estimated (MIT, 2014) to be 585 TJ/year from 2020 with the annual budget of 150 mil. CZK.

1.2.1.24. ICAO agreement

GHG affected: CO_2

Type of policy: Economic

Implementing entity: Ministry of Transport

Period of implementation: 2000 - 2035

Implemented in scenario: WAM

Category: 1.A.3 Transport

Characteristics of PaM: The International Civil Aviation Organization (ICAO) is a UN specialized agency to manage the administration and governance of the Convention on International Civil Aviation (Chicago Convention). ICAO cooperates with Member States (MS) and industry groups on international civil aviation Standards and Recommended Practices (SARPs) and policies in support of a safe, efficient, secure, economically sustainable and environmentally responsible civil aviation sector.

Mitigation Impact: The measure ‘ICAO agreement’ is related to the resolution A39-2 and A39-3 from 2016 about consolidation and continuation of policies regarding climate change. MS agreed not to increase GHG emissions in aviation in 2020 in comparison to 2005.

Additional information: MS also approved to increase fuel use efficiency by 2% in 2020 comparing to 2010. The emission reduction has been calculated by subtraction of supposed energy saving from air transport related total emissions. The total emission reduction of this measure is 5.9 kt. CO2 eq. in 2035 year.

1.2.1.25. Economic and tax tools for road vehicles

GHG affected: CO_2

Type of policy: Economic, Fiscal

Implementing entity: Ministry of Finance (Government)

Period of implementation: 2020 - 2030

Implemented in scenario: WAM

Category: 1.A.3 Transport

Characteristics of PaM: The objective is to encourage the use of less polluting vehicles. This group of measures involve: exemption from charging the use of transport infrastructure for battery electric/plug in hybrid/fuel cell vehicles and reduced rate of user charges/tolls for CNG/LNG vehicles (Road Infrastructure Law 13/1997 and its amendments), a road tax reduction for zero emission and low emission vehicles (Road Tax Law 190/1993 and its amendments), excise tax on fuel (Excise Law 353/2003) which supports alternative fuels with lower CO_2 emissions (e.g. compressed natural gas – CNG, bio fuels – tax free).

The Transport Policy 2014 – 2020 contains following aims:

- To apply measures minimizing negative impacts of traffic emissions and noise by appropriate transport infrastructure
- To promote low emission freight transport
- To gradually implement measures to decrease noise and vibrations in densely populated areas
- To minimize negative impacts of transport on public health and ecosystem stability
- The construction and reconstruction of traffic structures for functional permeability for animals
- Preferably strengthen the capacity of existing transport corridors before building new communications with similar transport capacity serving the same territory
- To reduce the dependence of transport on energy based on fossil fuels
- To introduce speed limits on motorways and highways (higher speed causes more energy consumption and higher emissions).

A shift from a road to modes with the lower impact on the environment (railway, waterway, the use of multimodal transport systems.

Mitigation Impact: The emission reduction will be achieved by the changed composition of fuel consumption – more alternative fuels and less petrol and diesel. Provided that no alternative fuels will be charged by excise tax, its consumption increases, and petrol and diesel consumption decreases equally. The total emission reduction of this measure is 38.4 kt. CO_2 eq. in 2035 year.

1.2.1.26. Road toll

GHG affected: CO_2

Type of policy: Fiscal

Implementing entity: Ministry of Transport (Government)

Period of implementation: 2020 - 2035

Implemented in scenario: WAM

Category: 1.A.3 Transport

Characteristics of PaM: This measure imposes currently a toll also for trucks with the weight more than 3.5 t. The range and price of road charging for freight vehicles will change. Only motorways and selected 1st class roads are charged now in the Czech Republic. In the future, it is expected that the toll road network will be extended to other 1st class roads and to selected 2nd class roads.

Mitigation Impact: The emission reduction has been calculated with a help of demand elasticity. Elasticity expresses how travel demand responds to transport price increases. The elasticity values for road transport were obtained from scientific literature (Dunkerley, et al., 2015). The total emission reduction of this measure is 190.5 kt. CO_2 eq. in 2035 year.

1.2.1.27. Further decrease of CO_2 emissions in 2025 and 2030

GHG affected: CO_2

Type of policy: Regulatory

Implementing entity: Ministry of Transport (Government)

Period of implementation: 2020 - 2030

Implemented in scenario: WAM

Category: 1.A.3 Transport

Characteristics of PaM: In 2019 year, the EC Directive No. 631 2019 setting CO_2 emission performance standards for new passenger cars and for new light commercial vehicles, and repealing Regulations (EC) No 443/2009 and (EU) No 510/2011 was adopted. By this Directive, the CO_2 emissions from new cars should decrease on 15 % in 2025 and 37.5 % in 2030 compared to 2021 year, when the specific emission limit 95 g / km should be achieved. The CO_2 emissions from new vans should decrease on 15 % in 2025 and 31 % in 2030 compared to 2021 year.

Mitigation Impact: This measure can be fulfilled only by massive introduction of electric vehicles. The emission reduction has been calculated by modification of activity data: decrease of vehicle kilometers of new cars with petrol and diesel engines and proportional increase of new cars with zero emissions. The total emission reduction of this measure is 5454 kt. CO_2 eq. in 2035 year.

1.2.1.28. Policies and measures in 1.A.4 Other sectors

1.2.1.29. Operational Program Environment 2014 - 2020

GHG affected: CO_2

Type of policy: Economic

Implementing entity: Ministry of Environment (Government)

Period of implementation: 2014 – 2020

Implemented in scenario: WEM

Categories: 1.A.4.a. Commercial/Institutional; 1.A.4.b. Residential

Characteristics of PaM: The aim of the Operational Program Environment 2014 – 2020 is to protect and improve the quality of the environment in line with the principles of sustainable development. Two priority axes relevant for GHG reductions are priority axis 2 - Improvement of Air Quality in human settlements and priority axis 5 – Energy Savings. For the programming period 2014 – 2020, the total allocation is expected to be more than € 3 billion including about € 1 billion for activities improving air quality and energy efficiency. The priority axis 5 promotes energy efficiency measures on reducing final energy consumption in all sectors and increased use of local renewable energy sources in the public sector. It also supports the exemplary role of public administration by subsidizing construction of new public buildings in passive energy standard.

The program projects are financed from the European Regional Development Fund (ERDF) and from the Cohesion Fund (CF).

In the priority axis 2 the following activities are supported:

- The replacement of boilers burning solid fuels with new boilers combusting biomass, liquid or gas fuels;
- The above replacements combined with other non-combustion sources of thermal energy;
- The above replacements combined with other non-combustion sources of thermal energy.

Mitigation impact: The expected programme energy savings shows the following table.

Tab. 1-26 Energy savings of Operational Program Environment 2014 – 2020

Energy savings [TJ]	2015	2020	2025	2030	2035	2040	2045	2050
	0	4 023	4 740	4 740	4 740	4 740	4 740	4 740

Using emission factors, which respect changes in the fuel mix in power and heat generation and in the final energy consumption, we obtain the following reductions in greenhouse gases emissions.

Tab. 1-2720 Emissions reduction related to energy savings of Operational Program Environment 2014 – 2020

Emissions reduction [kt CO_2 eq.]	2015	2020	2025	2030	2035	2040	2045	2050
	0.00	372.15	467.35	426.09	376.79	306.70	301.13	293.93

Besides energy savings, the programme supports use of RES as well. The programme document envisages installing 30 MWe in RES sources and heat production from RES of 150 TJ by 2023. With respect to development of fuel mix used for electricity and heat generation, the resulting mitigation impact will be:

Tab. 1-2821 Energy production from RES and reached emissions reduction of Operational Program Environment 2014 – 2020

	2015	2020	2025	2030	2035	2040	2045	2050
Electricity generation from RES [TJ]	0.0	7.9	7.9	7.9	7.9	7.9	7.9	7.9
Heat generation from RES [TJ]	0.0	150.0	150.0	150.0	150.0	150.0	150.0	150.0
GHG emissions reduction [kt CO_2 eq.]	0.0	17.8	15.7	14.6	13.3	11.6	11.6	11.6

Additional information: The expected program budget for energy savings and RES support is 23.6 bill. CZK (approx. 907.7 mill. €).

1.2.1.30. Programme PANEL/NEW PANEL/PANEL 2013+

GHG affected: CO_2

Type of policy: Economic

Implementing entity: State Housing Fund (Government)

Period of implementation: 2001 – 2020

Implemented in scenario: WEM

Category: 1.A.4.b. Residential

Characteristics of PaM: The Programme PANEL (PANEL 2013+ since 2013) offers low-interest loans for a complex of refurbishments and modernizations of block of flats leading to the improvement of the utility value and to substantial lifetime prolongation.

Projects supported include e.g.:

- Insulation of the building
- Replacement of old external doors and windows in order to decrease releasing of heat and outside noise
- Reparation and insulation of roofs
- Installation of a heating system regulation
- Modernization of a heating system, including the use of RES

- Repair or modernization of ventilation technology
- Installation of thermo-solar panels
- Installation of measurement devices for heat consumption, hot and cold water consumption
- Modernization of the hot water system (e.g., lever taps replacement, riser pipe insulation)
- Acquisition of building energy performance certificate

The programme is based on the Decree No. 299/2001 Coll. The aid can be obtained by:

- Physical or legal entities which own or co-own the building,
- Physical or legal entities which own or co-own a flat or a non-living space in the building
- A community of flat owners

Many kinds of refurbishments of multi-family houses are eligible for the support. The support can have the form of:

- A guarantee for the bank loan
- A subsidy of the credit interest

Mitigation impact: The expected programme energy savings shows the following table.

Tab. 1-2922 Expected energy savings of the PANEL programme

Energy savings [TJ]	2015	2020	2025	2030	2035	2040	2045	2050
	0	204	204	204	204	204	204	204

Using emission factors, which respect changes in the fuel mix in power and heat generation and in the final energy consumption, we obtain the following reductions in greenhouse gases emissions.

Tab. 1-30 Expected emissions reduction related to energy savings of the PANEL programme

Emissions reduction [kt CO_2 eq.]	2015	2020	2025	2030	2035	2040	2045	2050
	0.00	17.16	16.05	15.54	14.58	13.29	13.09	12.77

Additional information: The expected annual budget for the period 2014 – 2020 is estimated to be about 4.5 bill. CZK (MIT, 2017).

1.2.1.31. New Green Savings Programme 2014 – 2020

GHG affected: CO_2

Type of policy: Economic

Implementing entity: State Environmental Fund

Period of implementation: 2014 – 2020

Implemented in scenario: WEM

Category: 1.A.4.b. Residential

Characteristics of PaM: This programme is implemented by the State Environmental Fund of the Czech Republic. It aims at the improvement of energy performance of single- and multi-family buildings (replacement of old inefficient boilers by new boilers using e.g., (a) biomass, (b) installation of heat pumps and (c) solar systems for hot water).

The programme supports the following activities in single-family houses, multi-family houses and also in public sector buildings:

- Improvement of the energy performance of existing single- and multi-family buildings
- Construction of single- and multi-family buildings with very high energy performance

- Efficient use of energy sources (e.g., biomass boilers, biomass fireplace stoves with a heat exchanger, heat pumps, gas condensing boilers, solar systems for heating and hot water, installation of mechanical ventilation systems with heat recovery)

Mitigation impact: The expected programme energy savings shows the following table.

Tab. 1-231 Expected energy savings of the New Green Savings Programme 2014 – 2020

Energy savings [TJ]	2015	2020	2025	2030	2035	2040	2045	2050
	0	9 074	9 074	9 074	9 074	9 074	9 074	9 074

Using emission factors, which respect changes in the fuel mix in power and heat generation and in the final energy consumption, we obtain the following reductions in greenhouse gases emissions.

Tab. 1-32 Expected emissions reduction related to energy savings of the New Green Savings Programme 2014 – 2020

Emissions reduction [kt CO_2 eq.]	2015	2020	2025	2030	2035	2040	2045	2050
	0.00	529.50	467.67	437.83	404.26	364.01	358.21	349.63

Additional information: The expected annual budget for the period 2014 – 2020 is estimated to be about 18.7 bill. CZK (approx.719.2 mill. €) (MIT, 2017).

1.2.1.32. Integrated Regional Operating Programme

GHG affected: CO_2

Type of policy: Economic

Implementing entity: Ministry of Regional Development (Government)

Period of implementation: 2014 – 2020

Implemented in scenario: WEM

Categories: 1.A.4.a. Commercial/Institutional; 1.A.4.b. Residential;

Characteristics of PaM: The program is divided into following priority axes:

- Competitive, affordable and secure regions
- Improvement of public services and living conditions for residential regions
- Good governance and the efficiency of public institutions
- Community-led local development
- Technical assistance

The priority axis 2 and its investment priority 4c “Promoting energy efficiency, intelligent systems energy management and use of energy from renewable sources public infrastructures, including in public buildings and in housing” is dealing with energy savings.

Supported measures affecting the energy performance include:

- Insulation of residential building
- Replacement and refurbishment of windows and doors
- Passive heating and cooling, shielding,
- Installation of systems of controlled ventilation with heat recovery

Measures affecting equipment for space and water heating include:

- Replacement of space heating boilers using solid or liquid fossil fuels by efficient biomass boilers

- Replacement of water heating boilers using solid or liquid fossil fuels by efficient biomass boilers,
- Heat pumps
- Condensing gas boilers or equipment for combined electricity and heat generation using RES or natural gas and covering primarily the energy needs of buildings where located.

Mitigation impact: The expected programme energy savings shows the following table.

Tab. 1-33 Expected energy savings of the Integrated Regional Operating Programme

	2015	2020	2025	2030	2035	2040	2045	2050
Energy savings [TJ]	0	2 561	3 168	3 168	3 168	3 168	3 168	3 168

Using emission factors, which respect changes in the fuel mix in power and heat generation and in the final energy consumption, we obtain the following reductions in greenhouse gases emissions.

Tab. 1-34 Expected emissions reduction related to energy savings of the Integrated Regional Operating Programme

	2015	2020	2025	2030	2035	2040	2045	2050
Emissions reduction [kt CO_2 eq.]	0.00	164.08	248.65	240.83	225.96	205.91	202.73	197.81

Additional information: The expected annual budget for the period 2014 – 2020 is estimated to be about 13.2 bill. CZK (approx. 507.7 mill. €) (MIT, 2017).

1.2.1.33. Directive 2012/27/EU on energy efficiency (Article 5)

GHG affected: CO_2

Type of policy: Regulatory

Implementing entity: Ministry of Industry and Trade (Government)

Period of implementation: 2011 – 2030

Implemented in scenario: WEM

Category: 1.A.4.a.Commercial/Institutional

Characteristics of PaM: 3% of the total floor area of heated and/or cooled buildings owned and occupied by its central government has to be renovated each year to meet at least the minimum energy performance requirements.

1.2.1.34. Energy efficiency measures in residential sector in the period 2021-2030

GHG affected: CO_2

Type of policy: economic

Implementing entity: State Environmental Fund

Period of implementation: 2021 – 2030

Implemented in scenario: WAM

Category: 1.A.4.b. Residential

Characteristics of PaM: Measures will aim at the improvement of energy performance of single and multi-family buildings (thermal insulation, replacement of old inefficient boilers by new boilers).

Mitigation impact: The expected energy savings shows the following table.

Tab. 1-245 Expected energy savings of the energy efficiency measures in residential sector

	2015	2020	2025	2030	2035	2040	2045	2050
Energy savings [TJ]	0	0	11 500	23 000	23 000	23 000	23 000	23 000

Using emission factors, which respect changes in the fuel mix in power and heat generation and in the final energy consumption, we obtain the following reductions in greenhouse gases emissions.

Tab. 1-256 Expected emissions reduction related to energy efficiency measures in residential sector

	2015	2020	2025	2030	2035	2040	2045	2050
Emissions reduction [kt CO_2 eq.]	0	0	592.72	1 109.80	1 024.73	922.68	922.68	922.68

1.2.1.35. Energy efficiency measures in commercial and institutional sector in the period 2021-2030

GHG affected: CO_2

Type of policy: economic

Implementing entity: State Environmental Fund

Period of implementation: 2021 – 2030

Implemented in scenario: WAM

Category: 1.A.4.a.Commercial/Institutional

Characteristics of PaM: Measures will aim at the improvement of energy performance in commercial and institutional buildings (thermal insulation of buildings, replacement and refurbishment of windows and doors and installation of systems of controlled ventilation with heat recovery)

Mitigation impact: The expected energy savings shows the following table.

Tab. 1-267 Expected energy savings of the energy efficiency measures in commercial and institutional sector

	2015	2020	2025	2030	2035	2040	2045	2050
Energy savings [TJ]	0	0	5 250	10 500	10 500	10 500	10 500	10 500

Using emission factors, which respect changes in the fuel mix in power and heat generation and in the final energy consumption, we obtain the following reductions in greenhouse gases emissions.

Tab. 1-278 Expected emissions reduction related to energy efficiency measures in commercial and institutional sector

	2015	2020	2025	2030	2035	2040	2045	2050
Emissions reduction [kt CO_2 eq.]	0.00	0.00	295.07	559.28	525.53	481.88	481.88	481.88

1.3. Policies and Measures in Industrial Processes and Product Use sector

Policies and Measures (PaM) under Industrial Processes and Product Use (IPPU) sector are focused on reducing fluorinated greenhouse gas (F-gas) emissions which rapidly increase during last two decades. The legislative action for preventing F-gas emissions was taken on EU level but also worldwide. Currently, there is no planned additional PaM in the Czech Republic for reducing greenhouse gas emissions from IPPU.

1.3.1.1. Implementation of Regulation (EU) No 517/2014 on Fluorinated greenhouse gases

GHG affected: HFCs

Type of policy: Regulatory

Implementing entity: European Parliament and the Council

Period of implementation: 2015 - 2035

Implemented in scenario: WEM

Characteristics of PaM: Old Regulation (EC) No 842/2006 was replaced by Regulation (EU) No 517/2014 (F-gas regulation), which applies from 1st January 2015. The main scope of the new F-gas regulation is:

- Prevention of emissions of fluorinated greenhouse gases – sets requirements for leak checks, servicing, training of the staff, record keeping, recovery of the gases at the end of the equipment's life,
- Reduction of the quantity of HFCs placed on the market - banning the use of F-gases in equipment where less harmful alternatives are available also the volume of HFCs placed on the EU market will be limited.

Mitigation Impact: The main goal of the new F-Gas Regulation is to cut by 2030 the EU's F-gas emissions by two-thirds compared with 2014 levels.

Additional information: Producers/importers/exporters of more than 100 t CO_2 eq. of F-gases must communicate information via obligatory reporting. Since 2015 new system of quotas put in place.

1.3.1.2. Implementation of Directive 2006/40/EC (MAC Directive)

GHG affected: HFCs

Type of policy: Regulatory

Implementing entity: European Parliament and the Council

Period of implementation: 2008 - 2017

Implemented in scenario: WEM

Characteristics of PaM: Directive 2006/40/EC regulates use of F-gases with GWP higher than 150 in passenger cars (M1) and light commercial vehicles (N1) air conditioning. The directive consists from 3 phases, from which the last one entered into the force on 1st January 2017. Since that, the use of HFCs with GWP higher than 150 is totally banned for new vehicles which are placed on the EU market.

Mitigation Impact: Overall mitigation impact of the Directive 2006/40/EC on F-gases consumption in passenger cars (M1) and light commercial vehicles (N1) was calculated by using market information for year 2017. Car producers do not use F-gases (HFC-134a) for new cars intended for EU market but HFC-134a is used for filling of air conditioning of cars for non-EU countries. If the situation on the market remains stable in future, it is expected that emissions from 1st fill will decrease by 82% in 2035 comparing to year 2015. If the car producers will switch to use of alternatives (HFO-1234yf) also for cars intended for non-EU countries the mitigation impact will be 100% in 2035 compared to 2015.

1.3.1.3. Kigali Amendment to Montreal Protocol

GHG affected: HFCs

Type of policy: Regulatory

Implementing entity: European Parliament and the Council

Period of implementation: 2019 - 2036

Implemented in scenario: WEM

Characteristics of PaM: The Kigali Amendment reached agreement at 28th Meeting of the Parties to the Montreal Protocol on Substances that Deplete the Ozone Layer. The Kigali Amendment adds to the Montreal Protocol the phase-down of the use of HFCs. The Amendment sets a different time schedules and methodology for baseline calculations for Article 5 and non-Article 5 Parties.

Mitigation Impact: The starting point for the phase down of the use of HFCs for non-article 5 parties will be year 2019. Non-article 5 Parties should reduce production/consumption of HFCs by 85% relative to the baseline which is calculated as average production/consumption of HFCs in 2011 – 2013 plus 15% of HCFC baseline production/consumption.

Additional information: Trade with Parties that have not ratified the Amendment (“non-Parties”) will be banned from 1 January 2033.

1.4.Policies and Measures in Agriculture sector

The concept of sustainable and multifunctional agriculture in the Czech Republic takes into account the reduction of greenhouse gas emissions and possible needs for adaptation measures, along with other environmental and socio-economic considerations. These objectives can be achieved by the Common Agricultural Policy of the EU, as well as through national measures.

The implemented agrarian policies and measures should undoubtedly increase CO_2 fixation in the agriculture sector. The policies and measures in agriculture leading to greenhouse gas mitigation are based on prudent application of fertilizers, cultivation of cover crops, adoption of ecological and organic farming, implementation of modern and innovative technologies, monitoring fermentation of crop residues, etc. Recent agrarian policy has declared the goal of reducing nitrogen leaching and run-off.

Important measures to reduce emissions of GHGs in agriculture are optimal timing of fertilization, the exact amount of fertilizer application to crop use and optimal (covered) storage of manure.

The EU Common Agricultural Policy (CAP) has a significant relationship to the extent, orientation and profitability of agriculture. The common agricultural policy (CAP) in the EU is based on three principles – a common market for agricultural products based on common prices, preferences for agricultural production in the EU countries against external competition and financial solidarity - financing from common funds to which everyone pays contributions. The implementation of the CAP can affect the trend in GHG emissions from agriculture (methane and nitrous oxide emissions) in both directions (up or down) depending on the individual implemented measures, practices and policies in the Czech Republic.

On 16th December 2013 the Council of EU Agriculture Ministers formally adopted the 4 Basic Regulations for the reformed CAP as well as the Transition Rules for 2014. This follows on the approval of these Regulations by the European Parliament in November. On 20th December 2013 the four Basic Regulations and the Transition Rules were published in the Official Journal. With these new rules, the vast majority of CAP legislation will be defined under four following consecutive Regulations covering Rural development, "Horizontal" issues, Direct payments for farmers and Market issues:

- Regulation (EU) No 1307/2013 - Direct payments
- Regulation (EU) No 1308/2013 - Common organization of the markets
- Regulation (EU) No 1305/2013 - Rural development
- Regulation (EU) No 1306/2013 - Financing, management and monitoring
- Supporting Regulation (EU) No 1310/2013 - Transitional provisions

Agricultural direct payments are part of the first pillar of the EU Common Agricultural Policy. This policy had undergone a reform, which resulted into new rules for the period 2015-2020.

Direct Payments have been a key safety net and a driver for the modernization of agricultural holdings. In 2014, Czech farmers received around EUR 879 million in Direct Payments, benefitting 28 460 farmers and farm businesses. Some 7.3 % of Czech beneficiaries received a payment above EUR 100 000, relative to the EU-28 average of 0.45 %. Moreover, in 2014, the EU spent around EUR 15 million on market measures in the Czech Republic, primarily in the fruit and vegetables and wine sectors.

1.4.1.1. Cross Compliance

GHG affected: CH_4, N_2O, CO_2

Type of policy: Research, Education

Implementing entity: Ministry of Agriculture (Government)

Period of implementation: 2009 - 2035

Implemented in scenario: WEM

Characteristics of PaM: Cross compliance has been employed in the Czech Republic since 1 January 2009. The direct payments and other selected subsidies can be granted only on the condition that a beneficiary meets the statutory management requirements addressing the environment, public health, the health of animals and plants, and animal welfare, the standards of Good Agricultural and Environmental Conditions (GAEC), and minimum requirements for fertilizer and plant protection product use as part of agro-environmental measures.

Mitigation Impact: The implementation of Cross Compliance should reduce direct emissions from fertilizers (N_2O) and emissions from enteric fermentation (CH_4) by improvement of breeding management and a healthier animal population. This is a framework measure and its mitigation effect is accounted together with other PaMs in agriculture sector.

Additional information: In following years the cross compliance underwent number of updates which are in line with EU legislation, i.e., Common Agricultural Policy (CAP). The requirements and evaluated standards within Cross Compliance were updated in line with CAP.

1.4.1.2. Strategy for growth in Agriculture

GHG affected: CH_4, N_2O, CO_2

Type of policy: Economic

Implementing entity: Ministry of Agriculture (Government)

Period of implementation: 2013 - 2020

Implemented in scenario: WEM

Characteristics of PaM: The most of the national instruments implemented to the Czech agrarian strategy and policy. The long-term objective of the economically justified strategic level of production in the main agricultural commodities of the moderate belt / dairy products, meat, etc.) is taken into account, also ensuring adequate market share in the production of processed agricultural and food products, especially those for which, there is a potential for competitive production.

The document presents prognosis of activity data and targets of agricultural management also in terms of agro-environmental measures and policies.

Mitigation Impact: It is expected that GHG emissions reduction for year 2020 will be approximately 250 kt CO_2 eq. and 300 kt CO_2 eq. for year 2035.

1.4.1.3. Rural Development Program of the Czech Republic (2014-2020)

GHG affected: CH_4, N_2O, CO_2

Type of policy: Economic

Implementing entity: Ministry of Agriculture (Government)

Period of implementation: 2014 - 2020

Implemented in scenario: WEM

Characteristics of PaM: The principal objective of the program is to restore, preserve and improve the ecosystems dependent on agriculture by means of agri-environmental measures, to invest into the competitiveness and innovation of agricultural enterprises, to encourage young people into farming, or to improve landscape infrastructure. On the agri-climate measures is allocated ca. 1 % of the total amount.

In line with the strategy Europe 2020, those general objectives of rural development support in the period 2014–2020 are specified in six priorities applicable to the entire EU, where each measure may contribute to the objectives of several priorities. However, two of them are focused on climate change and renewable energy sources (P4 and P5).

The program will support diversification of rural economic activities with the aim of creating new jobs and enhancing economic development. It will support community-led local development and, more specifically, the LEADER method which contributes to better targeting of the support at the local needs of specific rural areas and to the development of cooperation among stakeholders at the local level. Its horizontal priority is sharing knowledge and innovation in the form of educational activities and consulting and collaboration in agriculture and forestry.

Mitigation Impact: It is expected the restoration, preservation or improvement of ecosystems and management methods on more than 1.3 million ha of agricultural and forest land.

Additional information: The European Commission approved the final version of the fundamental programming document of the Rural Development Programme of the Czech Republic for the period 2014-2020 in 2015. Rural Development Programme (RDP) is subsidized by nearly EUR 3.55 billion over the next years. Of that, EUR 2.3 billion will come from the EU sources and EUR 1.25 billion from the Czech budget.

1.4.1.4. Action Plan for the Development of Organic Farming in the CR (2016-2020)

GHG affected: CH_4, N_2O

Type of policy: Economic

Implementing entity: Ministry of Agriculture (Government)

Period of implementation: 2016 - 2020

Implemented in scenario: WEM

Characteristics of PaM: The main goal is to promote the growth of organic farming in the Czech Republic until 2020, particularly to harness the potential of organic farming in the nature protection, for research and innovation in organic farming, counselling or education.

Mitigation Impact: This is a framework measure and its mitigation effect is accounted together with other PaMs in agriculture sector.

1.4.1.5. Action Plan for biomass in the Czech Republic

GHG affected: CO_2

Type of policy: Economic

Implementing entity: Ministry of Agriculture (Government)

Period of implementation: 2012 - 2020

Implemented in scenario: WEM

Characteristics of PaM: The main aim of Action Plan for biomass in Czech Republic for period 2012 - 2020 is to define appropriate measures and principles that will help the effective and efficient use of the energy potential of biomass. The main objectives include a determination of energy potential of agricultural and forest woody biomass and quantifying the amount of energy that can be produced by biomass in the Czech Republic with a view to 2020.

Mitigation Impact: It is expected that GHG emissions reduction for year 2020 will be approximately 125 kt CO_2 eq. and 255 kt CO_2 eq. for year 2035.

1.4.1.6. Ministry of Agriculture Strategy with a view to the 2030

GHG affected: CH_4, N_2O

Type of policy: Economic

Implementing entity: Ministry of Agriculture (Government)

Period of implementation: 2016 - 2030

Implemented in scenario: WEM

Characteristics of PaM: The document is designed as an open living document and a fundamental basis for strategic management processes within the Ministry of Agriculture. Priorities, objectives and actions of the Strategy will be implemented in the relevant programs. The material was approved by the Government of the Czech Republic on 3rd May 2016.

Mitigation Impact: This is a framework measure and its mitigation effect is accounted together with other PaMs in agriculture sector.

1.4.1.7. Nitrate Directive – 4th Action Plan

GHG affected: N_2O

Type of policy: Regulatory

Implementing entity: Ministry of Agriculture (Government)

Period of implementation: 2016 - 2035

Implemented in scenario: WEM

Characteristics of PaM: Nitrates Directive (91/676/EEC) generally requires Member States to:

- monitor waters and identify waters which are polluted or are liable to be polluted by nitrates from agriculture
- establish a code of good agricultural practice to protect waters from this pollution
- promote the application by farmers of the code of good agricultural practice
- identify the area or areas to which an action program should be applied to protect waters from pollution by nitrates from agricultural sources
- develop and implement action programs to reduce and prevent this pollution in identified areas: action programs are to be implemented and updated on a four-year cycle
- monitor the effectiveness of the action programs and report to the EU Commission on progress

The Directive specifies the maximum amount of livestock manure which may be applied (as the amount of fertilizers containing nitrogen per hectare per year, i.e. 170 kg N/ha).

Since August 2016, the Fourth Action Plans has been implemented. The main changes are: the expansion of territory of vulnerable areas, the new specifications for prohibition and limits of fertilization, crop rotation and farming on slopes etc.

Mitigation Impact: It should be noted that the costs associated with implementation of the above measures and policies are not possible to estimate at present. They represent an inherent part of the landscape (agricultural and forest) management practice applied in accordance with the local environmental and other specific conditions. Hence, the implemented measures carry over its spatial heterogeneity and discerning the particular costs is not feasible.

1.5.Policies and Measures in Land use, Land Use Change and Forestry sector

The land use, land use change and forestry (LULUCF) sector is linked to Agriculture and some of the policies listed above in the chapter 1.4 are partly common for both sectors. Policies and measures in the LULUCF sector are generally focused on sustainable use of natural resources, preserving biodiversity and securing all functions and services that these resources provide to society.

Despite numerous EU policy processes that are linked to LULUCF such as the Ministerial Conference on the Protection of Forests in Europe (Forest Europe, http://www.foresteurope.org), Natura 2000 etc., none of those are prescriptive in terms of CO_2, CH_4 and N_2O and emissions and removals. Their effect on greenhouse gas balance of the LULUCF sector may be indirect, however, not practicably quantifiable. Similarly, the adopted Decision No 529/2013/EU (on accounting rules on greenhouse gas emissions and removals resulting from activities relating to land use, land-use change and forestry and on information concerning actions relating to those activities) is in principle not prescriptive with respect to concrete actions and targets in the LULUCF sector, but regulates accounting rules and providing information. On the other hand, the most recently adopted EU Regulation 2018/841 on the inclusion of greenhouse gas emissions and removals from land use, land use change and forestry in the 2030 climate and energy framework may represent a stronger incentive for actions in the LULUCF sector. Specifically, it adopts a new accounting framework for forestry based on forest reference level (FRL). Setting FRL is mandatorily based on continuation of forest management practices during the so-called Reference period of 2000-2009. These practices are projected to the period 2021 - 2030 with a limited possibility to exclude disturbances. Since the Czech forestry is currently (as of 2018) experiencing an unpreceded large-scale decline of spruce-dominated stands, the adopted accounting framework becomes very unfavourable for the national circumstances. This issue is expected to dramatically fuel the national policymaking associated with efforts to reform and stabilize the forestry sector and management of forest resources.

It should be noted that the costs associated with implementation of the below measures and policies are not possible to estimate at present. They represent an inherent part of the landscape (agricultural and forest) management practice applied in accordance with the local environmental and other specific conditions. Hence, the implemented measures carry over its spatial heterogeneity and discerning the particular costs is not feasible.

1.5.1.1. National Forest Program II

GHG affected: CO_2

Type of policy: Economic

Implementing entity: Ministry of Agriculture (Government)

Period of implementation: 2008 – 2018

Implemented in scenario: WEM

Characteristics of PaM: The most important land category of the Czech LULUCF sector in terms of greenhouse gas emission balance is Forest Land. Forestry in the Czech Republic is regulated by the Forestry Act (The Act no. 289/1995 Coll. on Forests and Amendments to some Acts), which is the principal legislative instrument. This instrument also does not specifically target carbon balance, but its provisions affect carbon budget and greenhouse gas emissions & removals in numerous ways indirectly.

Beyond the legislative above, the National Forest Program II for the period 2008 to 2013 (NLP II) is the basic national strategic document for forestry and forestry-related sectors. Implemented within the environmental pillar, specifically Key Action 6 lists the measures being or to be implemented to alleviate the impact of expected global climate change and extreme meteorological conditions. These measures generally focus on creating more resilient forest ecosystems by promoting diversified forest stand utilizing to the greatest possible extent natural processes, appropriate species composition and variability of silvicultural approaches, reflecting the current international treaties, agreements, conventions and EU directives.

Mitigation Impact: The policies and measures listed above are directly aimed at mitigation, although mitigation effect is expected in long-term perspective of several decades to century. The key aim of the above policies is adaptation of forest ecosystems to environmental change, including both climate and societal factors. Discerning mitigation effect is, due to numerous uncertainties involved, highly uncertain. In general, mitigation benefits of this PaM are expected to be minimal or even negative in the coming decades. However, it is expected to turn positive in the long-term perspective of functional ecosystems fulfilling the entire spectrum of expected functions, including mitigation.

1.5.1.2. Updated Recommendations for implementing the proposed measures of NLP II

GHG affected: CO_2

Type of policy: Economic

Implementing entity: Ministry of Agriculture (Government)

Period of implementation: 2018 - 2035

Implemented in scenario: WAM

Characteristics of PAM: The Conclusions of the Coordinating Council for the implementation of the National Forestry Program II (2013) summarized the recommendations for implementing the proposed measures of NLP II after lengthy consultations by forestry experts in the country. For the emission balance of the LULUCF sector, particularly important are the elaborated recommendations of Key Action 6 NLP II (MIT, 2014), which are directly aimed at reducing the impacts of global climate change and extreme weather events. These recommendations applicable to forestry are also carried over in the recently adopted National adaptation strategy (Adaptation strategy to climate change in the conditions of the Czech Republic; MoE 2015) and further elaborated in the associated National Action Plan for Adaptation adopted in 2017.

Mitigation Impact: The policies and measures listed above are directly aimed at mitigation, although mitigation effect is expected in long-term perspective of several decades to century. The key aim of the above policies is adaptation of forest ecosystems to environmental change, including both climate and societal factors. Discerning mitigation effect is, due to numerous uncertainties involved, highly uncertain. In general, mitigation benefits of this PaM are expected to be minimal or even negative in the coming decades. However, it is expected to turn positive in the long-term perspective of functional ecosystems fulfilling the entire spectrum of expected functions, including mitigation. The model-assisted estimation of impacts to mitigation until 2040 is shown in chapter 2.5.

1.6.Policies and Measures in Waste sector

Greenhouse gas (GHG) emissions generated by the 5. Waste sector in the Czech Republic have been growing due to organic carbon accumulated in landfills, increasing amount of produced municipal solid waste (MSW) and unfavorable mix of MSW treatment options. Recently this trend started to turn and we observe mild stagnation of emissions from landfills, which is a key source of this sector in the Czech Republic. The observed slowing is mainly due to increased landfill gas (LFG) capturing.

There is a potential for emission reductions in fulfilling the EU obligations of the Circular Economy Package (CEP) (EC, 2018) and other national measures with emission reduction effects which are related to the common waste policy described in the Waste Management Plan 2014 (WMP). 5.C Waste incineration measures also affect industrial waste generated by other industries. Policies and measures (PaM) in the waste sector aim at reducing the amount of produced waste, minimizing the delivery of the biodegradable waste in landfills, establishing and expanding separate collection of hazardous household waste, bio-waste and textiles, promoting the incineration and digestion of non-recyclable waste, increasing the landfill gas recovery and improving of the waste water treatment in sparsely populated areas.

The Czech waste legislation is largely based on EU legislation. The EU legislation with direct impact on GHG emissions from waste included Landfill Directive (1999/31/EC) and Waste Directive (2006/12/EC) but those are now replaced by the CEP (EC, 2018). The assumption is that the new obligations and recycling targets of the CEP will be met. See chapter 1.6 for more details about the new targets.

Several policies are not part of the waste legislation already have or will have impact on GHG emissions from 5. Waste. Most of them are mentioned in the cross sectoral division of this report but above all it is worth to mention EU Emissions Trading System (ETS), Climate & Energy Package and Energy Tax Directive which provide direct and indirect support on LFG recovery and therefore, are influencing landfill emissions significantly.

The largest public financial support for the waste management infrastructure comes from Czech State Environmental Fund (SEF). The Operational Programme Environment (OPE) contributes also significantly to the expansion of the facility network and is financed from EU Cohesion Fund (MoE, 2014).

1.6.1.1. Circular Economy Package (CEP)

GHG affected: CH_4

Type of policy: Economic, Fiscal

Implementing entity: Ministry of Environment (Government)

Period of implementation: 2018 - 2030

Implemented in scenario: WEM

Characteristics of PaM: European Commission describes the CEP (EC, 2018)as the revised legislative proposals on waste setting targets for reduction of waste and establishing a long-term path for waste management and recycling (EC, 2018). Key elements of the revised waste proposal include:

- a common EU target for recycling 65% of municipal waste by 2030;
- a common EU target for recycling 75% of packaging waste by 2030;
- a binding landfill target to reduce landfill to maximum of 10% of municipal waste by 2030;
- a ban on landfilling of separately collected waste;
- promotion of economic instruments to discourage landfilling;

- simplified and improved definitions and harmonised calculation methods for recycling rates throughout the EU;
- concrete measures to promote re-use and stimulate industrial symbiosis - turning one industry's by-product into another industry's raw material;
- economic incentives for producers to put greener products on the market and support recovery and recycling schemes (EC, 2018).

Mitigation impact: The assumption is that by obliging with the CEP 2030 targets the GHG reduction target will be met too.

Additional information:

1.6.1.2. Waste Management Plan 2014

GHG affected: CH_4

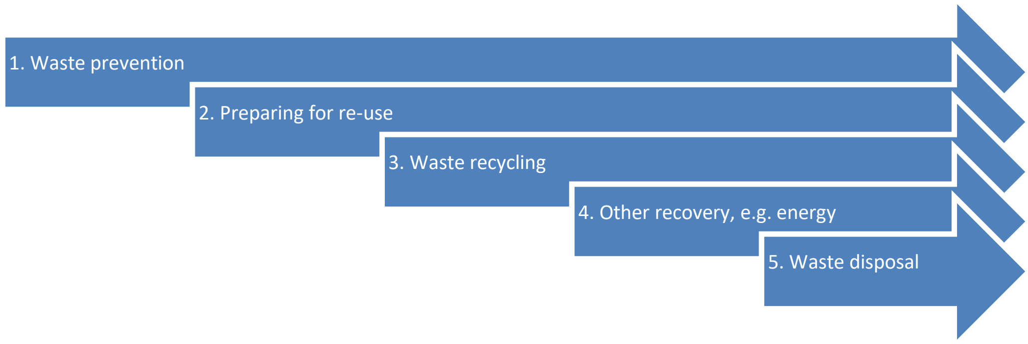
Type of policy: Economic, Fiscal

Implementing entity: Ministry of Environment (Government)

Period of implementation: 2015 – 2024

Implemented in scenario: WEM

Characteristics of PAM: The most important instrument on the national level is the Waste management plan (WMP) (MoE, 2014). The projections are based on the new WMP (MoE, 2014) adopted in 2014 that should be valid up to 2024. The WMP (MoE, 2014) contains exhaustive list of measures that are implemented and will be implemented in upcoming period. The binding part contains the objectives, principles, and measures that take into account environmental policy of the Czech Republic, European commitments of the Czech Republic and the needs of the current waste management in the Czech Republic. The binding part of the WMP (MoE, 2014) of the Czech Republic, is based on the principle of respect for the waste management hierarchy which is:



The WMP (MoE, 2014) was drawn up with consideration of the following PaMs related to GHG emissions from waste management:

- State Environmental Policy of the Czech Republic 2012-2020 (updated in 2016); defines a plan for implementation of effective environmental protection in the Czech Republic until 2020.
- Raw Material Policy of the Czech Republic 2012-2032 aims to ensure the State's raw material security, reflecting the economic developments in Europe and in the world, as well as the changes in the global raw materials market.
- The Secondary Raw Materials Policy of the Czech Republic – the basic vision of this document is "turning waste into resource." The Policy provides favourable conditions for the "secondary

raw materials" processing and recovery from products and materials, which completed their life cycle. The main objective is to replace the primary natural resources by the "secondary raw materials" and so contribute to reduction of the intensity of material and energy production.

- Biomass Action Plan of the Czech Republic 2012-2020 presents an analysis of the biomass use in the Czech Republic for energy purposes and proposes appropriate sustainability measures of the intersection between 3. Agriculture and 1. Energy sector until 2020.
- State Energy Policy of the Czech Republic defines objectives of the state in the energy management according to the need for economic and social development, including environmental protection and development of territorial energy concepts.

The current WMP (MoE, 2014) includes modelling of the proposed and implemented measures and their impact on activity data – waste quantity and waste management practices. Result of this modelling was used as a basis for the projections of GHG emissions in this material.

Mitigation impact: During 2017 - 2018 the waste management options developed as follows: material recovery rose 4%, composting rose 4%, energy recovery decreased -1%, and landfilling increased 3%. The projected impact for the 2015 - 2024 waste management options is 41%, 111%, 30% and -38%, respectively for the above categories. The assumption for GHG emission reduction is 0.15Mt CO_2 eq. or 3% over the period of 2015 – 2024, but comparing the 2024 estimate to the 2005 value, emissions will have increased by 1.03 Mt CO_2 or 24%. Over the period of 2005 - 2018 GHG emissions rose by 1.35 Mt CO_2 eq. or 33%. Above are not official impact values for the GHG reductions. Official impact values are in other documents as in the Biennial Report and in the National Communications.

Additional information: The OPE 2014 – 2020 is a direct continuation of OPE 2007-2013 and is also financed from the EU Cohesion Fund (MoE, 2014). The priorities of project support in waste management are determined by the obligations of the CEP (EC, 2018), the WMP (MoE, 2014) and also by the Programme of waste prevention of the Czech Republic (MoE, 2014a). From 468 million EUR, 19.2 million EUR is allocated for preventing municipal waste generation, 44 million EUR for preventing industrial waste generation, 68 million EUR for construction and modernization of waste collection, sorting and treatment facilities, 104 million EUR for material recovery of waste, 52 million EUR for energy recovery of waste and 22.8 million EUR for construction and modernization of hazardous waste management facilities. A currency converter of 25 CZK = 1 EUR was applied.

2 Projected greenhouse gas emissions by gas and source

2.Projected GHG emissions by gas and source

Projections of greenhouse gas (GHG) emissions are prepared for following sectors:

- Energy,
- Industrial Processes and Product Use (IPPU),
- Agriculture,
- Land Use, Land Use Change and Forestry (LULUCF),
- Waste.

The preparation of GHG emissions projections include the following steps:

(i) Selection of the latest available National Inventory Report (NIR) – The currently available NIR (CHMI, 2020) contains GHG emission estimates for above listed sectors for period 1990 - 2018. According to NIR (CHMI, 2020), the total GHG emissions (including indirect emissions and LULUCF) were 134 Mt CO_2 eq. in 2018. Emissions decreased in 2018 by 31% compared to 1990. Total emissions including indirect emissions and excluding LULUCF were 128 Mt CO_2 eq. in 2018. Emissions decreased in 2018 by 36% compared to 1990.

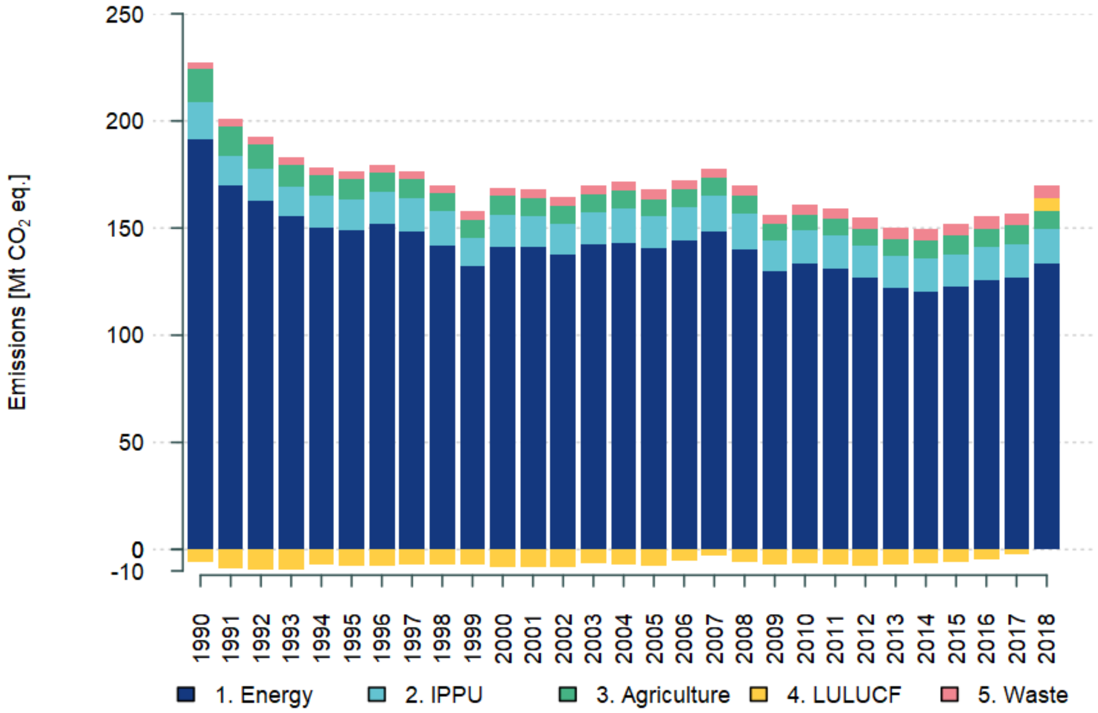


Fig. 2-1 Total GHG emissions of the Czech Republic for 1990 – 2018 (CHMI, 2020)

The total trend of GHG emission estimates (including LULUCF) published in NIR (CHMI, 2020) are shown in

Tab. 2-1 and Fig. 2-1. The highest share of GHG emissions in 2018 has sector 1. Energy (73%), where 97% comes from 1.A Fuel combustion. The share of other sectors on total GHG emissions is following: 2. IPPU 12%, 3. Agriculture 4% and 5. Waste 4%. 4. LULUCF is usually the only sector acting as GHG sink, however in 2018 it contributed to the balance as an emitter by 4% due to the bark beetle mitigation measures.

Tab. 2-1 Overview of GHG emission/removal trends by CRF categories (CHMI, 2020)

	Base year kt CO_2 eq.	2018 kt CO_2 eq.	2018 Total share [%]	2018 Sectoral share [%]	Trend [%]
1. Energy	**161316.31**	**96875.7**	**72.71**	**100**	**-39.95**
A. Fuel combustion (sectoral approach)	149454.8	93553.78	70.21	96.57	-37.4
1. Energy industries	56855.14	51071.61	38.33	52.72	-10.17
2. Manufacturing industries and construction	47113.14	9958.91	7.47	10.28	-78.86
3. Transport	11484.85	19055.34	14.3	19.67	65.92
4. Other sectors	33807.41	13145.64	9.87	13.57	-61.12
5. Other	194.26	322.28	0.24	0.33	65.9
B. Fugitive emissions from fuels	11861.51	3321.92	2.49	3.43	-71.99
1. Solid fuels	10779.39	2713.91	2.04	2.8	-74.82
2. Oil and natural gas and other emissions from energy production	1082.12	608.01	0.46	0.63	-43.81
C. CO_2 transport and storage	NO	NO	NA	NA	0
2. Industrial Processes	**17113.01**	**16262.9**	**12.21**	**100**	**-4.97**
A. Mineral industry	4082.45	3077.63	2.31	18.92	-24.61
B. Chemical industry	2944.23	2047.56	1.54	12.59	-30.46
C. Metal industry	9670.32	6948.64	5.21	42.73	-28.14
D. Non-energy products from fuels and solvent use	125.56	154.48	0.12	0.95	23.03
E. Electronic industry	NO,NE	6.64	0	0.04	100
F. Product uses as ODS substitutes	NO	3736.79	2.8	22.98	100
G. Other product manufacture and use	290.46	291.13	0.22	1.79	0.23
H. Other	NO	0.04	NA	NA	100
3. Agriculture	**15648.71**	**8606.5**	**6.46**	**100**	**-45**
A. Enteric fermentation	5600.62	3039.43	2.28	35.32	-45.73
B. Manure management	3124.7	1050.44	0.79	12.21	-66.38
C. Rice cultivation	NO	NO	NA	NO	0
D. Agricultural soils	5627.23	4229.33	3.17	49.14	-24.84
E. Prescribed burning of savannas	NO	NO	NA	NO	0
F. Field burning of agricultural residues	NO	NO	NA	NO	0
G. Liming	1187.63	161.37	0.12	1.87	-86.41
H. Urea application	108.53	125.92	0.09	1.46	16.03
I. Other carbon-containing fertilizers	NO	NO	NA	NA	0
J. Other	NO	NO	NA	NA	0
4. Land use, land-use change and forestry	**-5686.64**	**5794.15**	**4.35**	**100**	**-201.89**
A. Forest land	-4373.15	7320.36	5.49	126.34	-267.39
B. Cropland	214.82	99.56	0.07	1.72	-53.65
C. Grassland	-110.23	-282.26	-0.21	-4.87	156.05
D. Wetlands	21.73	20.36	0.02	0.35	-6.34
E. Settlements	271.17	124.07	0.09	2.14	-54.25
F. Other land	NO,NA	NO,NA	NA	NO	0
G. Harvested wood products	-1712.98	-1488.47	-1.12	-25.69	-13.11
H. Other	NO	NO	NA	NA	0
5. Waste	**3124.51**	**5704.49**	**4.28**	**100**	**82.57**
A. Solid waste disposal	1979.27	3742.72	2.81	65.61	89.1
B. Biological treatment of solid waste	NE,IE	721.07	0.54	12.64	100
C. Incineration and open burning of waste	21.25	141.03	0.11	2.47	563.53
D. Waste water treatment and discharge	1123.99	1099.67	0.83	19.28	-2.16
E. Other	NO	NO	NA	NA	0
Total CO_2 equivalent emissions without land use, land-use change and forestry	**197202.55**	**127449.6**			**-35.37**
Total CO_2 equivalent emissions with land use, land-use change and forestry	**191515.91**	**133243.75**			**-30.43**
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry	**199067.16**	**128139.42**			**-35.63**
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land- use change and forestry	**193380.53**	**133933.57**			**-30.74**

(ii) Selection of base, final, and cross-cutting years for projections – 2018 was selected as the base year for GHG emissions projections, as it is the latest year with available information on macroeconomic development, energy balances and emission estimates. 2050 was selected as the final year, according to the recommendations of the EU. 2020, 2025, 2030, 2035, 2040, 2045, and 2050 were selected as the cross-cutting years.

(iii) Selection of the methodology and model instruments for the projection preparation – Detailed methodology and modeling instruments used for GHG emissions projections can be found in chapter Methodological issues for each sector.

(iv) Collection and analysis of input data for the projection – More detailed information about collection and analysis of input data used for GHG emissions projections can be found in chapter Methodological issues for each sector.

(v) Establishment of initial assumptions – More detailed information about initial assumptions used for GHG emissions projections can be found in chapter Methodological issues for each sector.

(vi) Definition of scenarios – GHG emission projections contain two scenarios: 'With existing measures' (WEM) and 'With additional measures' (WAM). Policies and measures (PaM) introduced before 1st July 2020 are reflected in WEM scenario, while PaMs introduced after 1st July 2020 are reflected in WAM scenario. More detailed information about PaMs and their implementation can be found in chapter 1. Policies and Measures.

(vii) Calculation of scenarios and results presentation – Results of GHG emission projections are presented for each sector as a total emission for sector, emissions by gases and emissions by categories. Results can be found in chapter Projected greenhouse gas emissions 'With measures (WEM) scenario' and 'With additional measures (WAM) scenario' for each sector.

(viii) Sensitivity analysis on selected assumptions – Detailed information are available in chapter Sensitivity analysis for each sector.

2.1.Projected greenhouse gas emissions 'With measures (WEM) scenario' and 'With additional measures (WAM) scenario'

The total GHG emissions (Tab. 2-2 and

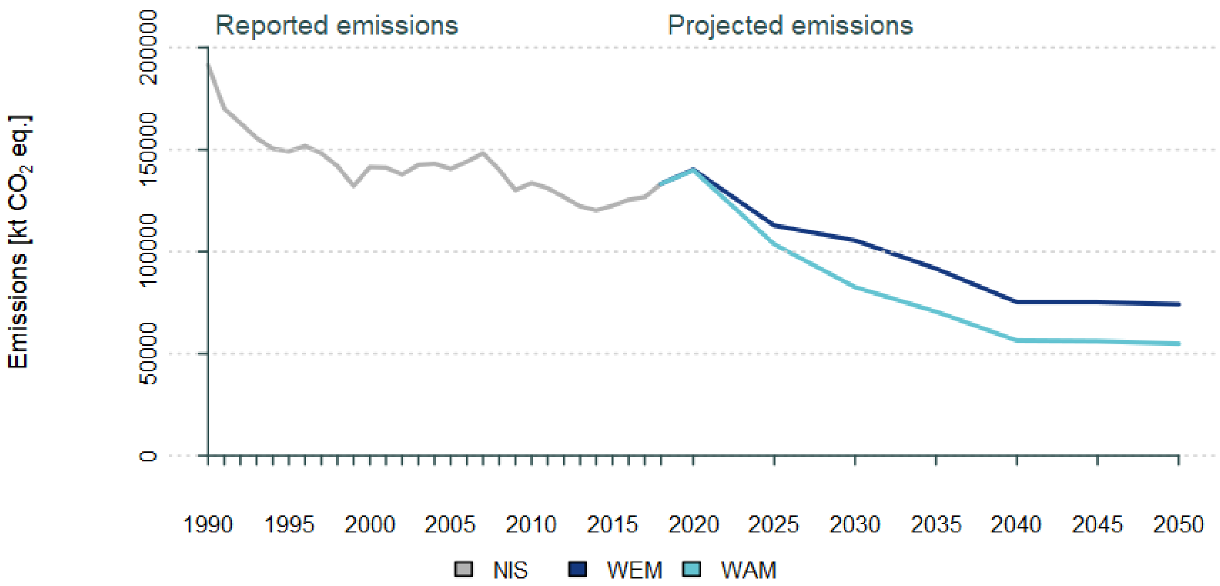


Fig. 2-2) are projected to slightly increase in next few years for both WEM and WAM scenarios. Around the 2025 the emissions will start to decrease and the declining trend continues until 2040 when it flattens and stays stagnant until 2050. The difference between WEM and WAM scenario is caused by additional measures in 1. Energy, 4. LULUCF and 5. Waste. Total GHG emissions for WEM scenario are projected to amount to 74.15 Mt CO_2 eq. in 2050, representing 61% decrease of emissions compared to 1990. For WAM scenario the total GHG emissions in 2050 will amount to 54.86 Mt CO_2 eq., representing 71 % decrease of emissions compared to 1990.

Tab. 2-2 Reported and projected emissions of GHG – WEM and WAM (including LULUCF)

[Mt CO_2 eq.]	Reported emissions			Projected emissions							Difference [%]			
	1990	2005	2018	2020	2025	2030	2035	2040	2045	2050	1990 – 2020	1990 – 2030	1990 – 2040	1990 - 2050
WEM	191.52	140.57	133.24	140.20	112.78	105.46	91.65	75.26	75.24	74.15	-26.80	-44.94	-60.70	-61.28
WAM	191.52	140.57	133.24	139.88	103.59	82.59	70.56	56.35	56.05	54.86	-26.96	-56.88	-70.58	-71.36

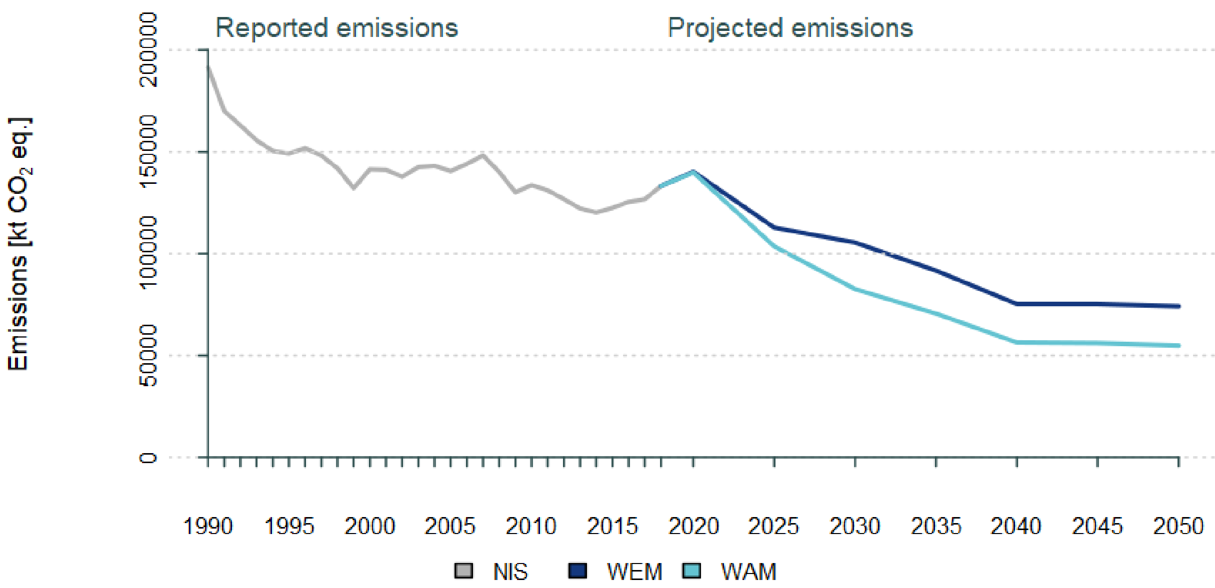


Fig. 2-2 Reported and projected GHG emissions – WEM, WAM scenario (including LULUCF)

2.1.1.1. Projected greenhouse gas emissions 'With measures (WEM) scenario'

According to the WEM scenario it is expected that emissions will decrease for all the monitored GHG except of N_2O. Emissions of N_2O shall increase in 2020 – 2050; increase is caused mainly due to increase of emissions from 3. Agriculture (for more details please see chapter 2.3). While previously the highest decline of emissions was projected for F-gases, due to the regulation of F-gas consumption on EU level, CH_4 and CO_2 are projected to catch up with its trend.

Tab. 2-3 Breakdown of reported and projected emissions of GHG - WEM scenario (including LULUCF)

[Mt CO_2 eq.]	Reported emissions			Projected emissions							Difference [%]			
	1990	2005	2018	2020	2025	2030	2035	2040	2045	2050	1990 – 2020	1990 – 2030	1990 – 2040	1990 - 2050
CO_2	158.46	117.67	111.08	118.07	93.56	87.65	75.47	60.15	60.55	59.68	-25.49	-44.68	-62.04	-62.33
CH_4	23.53	14.68	13.18	12.79	11.16	10.51	9.46	8.68	8.19	8.05	-45.66	-55.34	-63.10	-65.81
N_2O	9.45	6.14	6.09	5.57	5.54	5.57	5.59	5.58	5.78	5.79	-41.03	-41.02	-40.93	-38.74
HFCs	NO	1.07	3.74	3.70	2.46	1.66	1.08	0.79	0.67	0.59	NA	NA	NA	NA
PFCs	NO	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	NA	NA	NA	NA
SF_6	0.08	0.11	0.07	0.07	0.06	0.05	0.04	0.04	0.04	0.03	-20.33	-40.05	-53.01	-61.38
NF_3	NO	NO	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	NA	NA	NA	NA
Total	**191.52**	**140.57**	**133.24**	**140.20**	**112.78**	**105.46**	**91.65**	**75.26**	**75.24**	**74.15**	**-26.80**	**-44.94**	**-60.70**	**-61.28**

Projected trend of GHG emissions for individual sectors (Tab. 2-4) shows the most rapid decrease in 1990 – 2050 for 1. Energy (65%). 2. IPPU is expected to decrease F-gas emissions but emissions related to e.g. mineral, chemical, iron and steel production are not anticipated decrease rapidly, as production capacity of facilities are expected to remain the same during next decades. GHG in 3. Agriculture are expected to increase slightly during the projected period (2050), mainly due to the planned increase of animal population. According to the LULUCF projections, the sector is expected to remain a GHG emitter until 2025 after which it should regain its place as a GHG sink. This is caused mainly due to the bark beetle infestations. Decrease of GHG emissions by 2050 in comparison with the current level (2018) is expected for Waste sector.

Tab. 2-4 Breakdown of reported and projected emissions of GHG by sectors - WEM scenario (including LULUCF)

[Mt CO_2 eq.]	Reported emissions			Projected emissions							Difference [%]			
	1990	2005	2018	2020	2025	2030	2035	2040	2045	2050	1990 – 2020	1990 – 2030	1990 – 2040	1990 - 2050
1. Energy	161.32	120.60	96.88	97.29	83.85	80.56	71.21	57.58	56.75	55.72	-39.69	-50.06	-64.31	-65.46
2. IPPU	17.11	14.83	16.26	16.16	14.67	13.86	13.18	12.85	12.88	12.77	-5.59	-19.01	-24.91	-25.35
3. Agriculture	15.65	8.18	8.61	8.14	8.17	8.37	8.49	8.67	8.72	8.82	-48.00	-46.52	-44.62	-43.65
4. LULUCF	-5.69	-7.33	5.79	12.96	0.76	-1.98	-5.07	-7.19	-6.19	-6.07	-327.89	-65.11	26.49	6.82
5. Waste	3.12	4.29	5.70	5.66	5.33	4.65	3.84	3.35	3.08	2.92	81.07	48.95	7.30	-6.50
Total	**191.52**	**140.57**	**133.24**	**140.20**	**112.78**	**105.46**	**91.65**	**75.26**	**75.23**	**74.16**	**-26.80**	**-44.94**	**-60.71**	**-61.28**

2.1.1.2. Projected greenhouse gas emissions 'With additional measures (WAM) scenario'

The difference between WEM and WAM scenario is due to additional measures included in WAM scenario for 1. Energy, 4. LULUCF and 5. Waste. The difference between the WEM and WAM scenarios gradually increases between 2020 and 2050. From the perspective of individual GHGs, the trend very similar to the WEM scenario.

Tab. 2-5 Breakdown of reported and projected emissions of GHG - WAM scenario

[Mt CO_2 eq.]	Reported emissions			Projected emissions							Difference [%]			
	1990	2005	2018	2020	2025	2030	2035	2040	2045	2050	1990 – 2020	1990 – 2030	1990 – 2040	1990 - 2050
CO_2	158.46	117.67	111.08	117.75	84.46	64.90	54.50	41.43	41.62	40.71	-25.69	-59.05	-73.85	-74.31
CH_4	23.53	14.68	13.18	12.79	11.08	10.43	9.38	8.53	7.97	7.76	-45.66	-55.66	-63.74	-67.03
N_2O	9.45	6.14	6.09	5.57	5.53	5.54	5.56	5.55	5.74	5.75	-41.06	-41.35	-41.29	-39.10
HFCs	NO	0.79	3.74	3.70	2.46	1.66	1.08	0.79	0.67	0.59	NA	NA	NA	NA
PFCs	NO	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	NA	NA	NA	NA
SF_6	0.08	0.11	0.07	0.07	0.06	0.05	0.04	0.04	0.04	0.03	-20.33	-40.05	-53.01	-61.38
NF_3	NO	NO	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	NA	NA	NA	NA
Total	**191.52**	**140.57**	**133.24**	**139.88**	**103.59**	**82.59**	**70.56**	**56.35**	**56.05**	**54.86**	**-26.96**	**-56.88**	**-70.58**	**-71.36**

The projected GHG emissions trend for individual sectors in WAM scenario (Tab. 2-6) is very similar to that of WEM scenario. According to the WAM scenario, emissions from 1. Energy and 5. Waste should be lower compared to WEM scenario.

Tab. 2-6 Breakdown of reported and projected emissions of GHG by sectors - WAM scenario

[Mt CO_2 eq.]	Reported emissions			Projected emissions							Difference [%]			
	1990	2005	2018	2020	2025	2030	2035	2040	2045	2050	1990 – 2020	1990 – 2030	1990 – 2040	1990 - 2050
1. Energy	161.32	120.60	96.88	96.97	74.73	57.76	50.19	38.81	37.77	36.70	-39.89	-64.19	-75.94	-77.25
2. IPPU	17.11	14.83	16.26	16.16	14.67	13.86	13.18	12.85	12.88	12.77	-5.59	-19.01	-24.91	-25.35
3. Agriculture	15.65	8.18	8.61	8.14	8.17	8.37	8.49	8.67	8.72	8.82	-48.00	-46.52	-44.62	-43.65
4. LULUCF	-5.69	-7.33	5.79	12.96	0.76	-1.98	-5.07	-7.19	-6.19	-6.07	-327.89	-65.11	26.49	6.82
5. Waste	3.12	4.29	5.70	5.66	5.26	4.59	3.77	3.21	2.87	2.65	81.07	46.76	2.87	-15.25
Total	**191.52**	**140.57**	**133.24**	**139.88**	**103.60**	**82.59**	**70.56**	**56.35**	**56.05**	**54.86**	**-26.96**	**-56.87**	**-70.58**	**-71.35**

2.1.1.3. Split of greenhouse gas emissions between EU ETS and ESD sectors

Following tables contain historic and projected greenhouse gas emissions under EU ETS sectors and ESD sectors for WEM and WAM scenario.

Tab. 2-7 Split of historic and projected EU ETS and ESD emissions – WEM scenario

[Mt CO_2 eq.]	Reported emissions		Projected emissions							Difference [%]			
	2005	2018	2020	2025	2030	2035	2040	2045	2050	2005 – 2020	2005 – 2030	2005 – 2040	2005 - 2050
EU ETS	82.50	62.92	66.32	58.15	57.40	49.51	37.44	37.66	37.20	-19.62	-30.43	-54.61	-54.91
ESD	64.50	64.53	60.92	53.87	50.05	47.22	45.01	43.77	43.04	-5.55	-22.41	-30.22	-33.28

Tab. 2-8 Split of historic and projected EU ETS and ESD emissions – WAM scenario

[Mt CO_2 eq.]	Reported emissions		Projected emissions							Difference [%]			
	2005	2018	2020	2025	2030	2035	2040	2045	2050	2005 – 2020	2005 – 2030	2005 – 2040	2005 - 2050
EU ETS	82.50	62.92	66.32	54.11	44.39	38.64	28.85	29.06	28.60	-19.62	-46.20	-65.03	-65.33
ESD	64.50	64.53	60.61	48.72	40.19	36.99	34.69	33.17	32.33	-6.03	-37.69	-46.21	-49.87

2.2.Energy

The 1. Energy sector in the Czech Republic is driven by the combustion of fossil fuels in stationary and mobile sources; however, fugitive emissions are also an important source of emissions. The two main categories are 1.A Fuel combustion and 1.B Fugitive emissions from fuels.

CO2 emissions from the category 1.A Fuel compustion decreased by 38%, from 147 Mt in 1990 to 92 Mt in 2018. Furthermore, CO2 emissions from the 1.B Fugitive emissions from fuels decreased by 77% from 458 kt in 1990 to 104 kt in 2018, as well as CH4 emissions from 1.B Fugitive emissions from fuels decreased by 72% from 456 kt in 1990 to 129 kt in 2018. GHG emission trend from sector 1. Energy for 1990 - 2018 is depicted in Fig. 2-3 (CHMI, 2020).

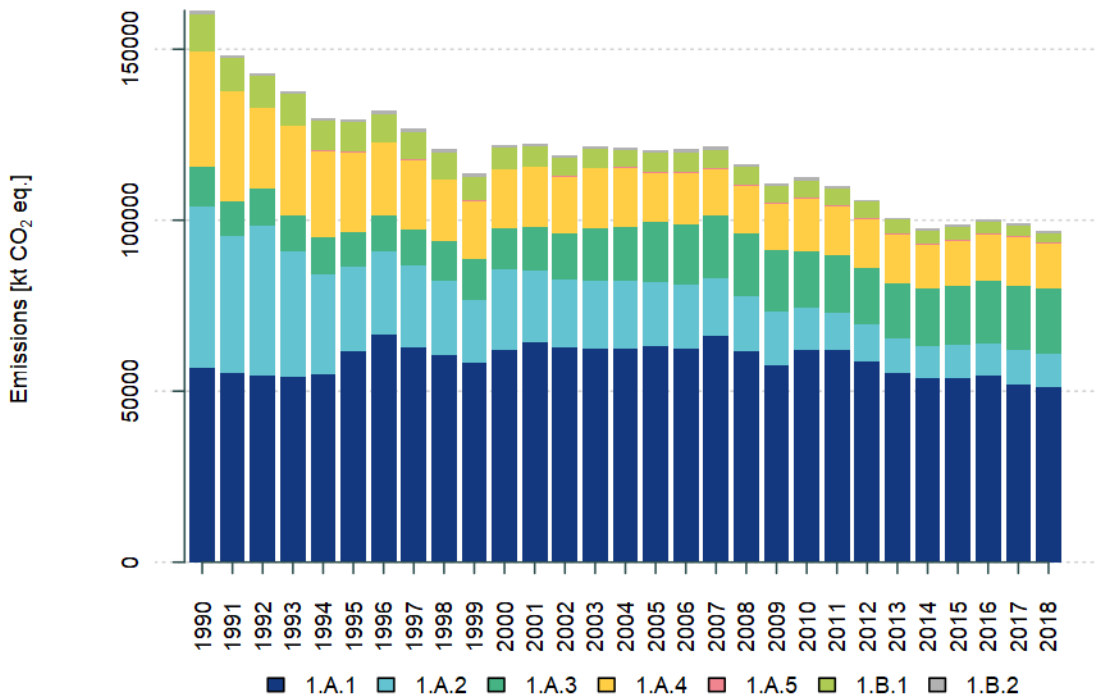


Fig. 2-3 The emission trend in 1. Energy during reporting period 1990 – 2018 (CHMI, 2020)

year	CO_2 kt	CH_4 kt	N_2O kt
1990	147 241	531.02	2.68
1991	135 653	477.92	2.46
1992	131 020	449.17	2.40
1993	125 999	440.07	2.30
1994	118 688	416.93	2.25
1995	118 539	406.86	2.26
1996	121 230	402.61	2.29
1997	116 267	392.52	2.23
1998	110 799	369.84	2.18

1999	104 551	336.34	2.17
2000	113 792	307.22	2.31
2001	114 506	292.68	2.13
2002	111 659	273.67	2.12
2003	114 208	270.95	2.18
2004	114 222	260.45	2.21
2005	113 017	276.74	2.22
2006	112 885	286.00	2.26
2007	114 173	268.58	2.30
2008	109 167	267.08	2.26
2009	103 919	254.36	2.17
2010	105 375	258.78	2.17
2011	102 962	257.73	2.19
2012	99 155	249.92	2.14
2013	94 716	214.84	2.10
2014	91 798	211.10	2.12
2015	92 994	206.94	2.17
2016	94 671	194.13	2.21
2017	93 827	181.04	2.21
2018	92 006	168.80	2.18
Trend 1990 - 2018	**-38%**	**-68%**	**-19%**

Tab. 2-9 The emission trend in 1. Energy during reporting period 1990 – 2018 (CHMI, 2020)

Projections of greenhouse gas (GHG) emissions from sector 1. Energy are prepared by two different methodological approaches for following categories:

Projections of emissions from categories 1.A.1, 1.A.2, 1.A.4, 1.A.5, 1.B.1 and 1.B.2 – projections are prepared using a data-driven model structure.

Projections of emissions from category 1.A.3 – projections are prepared by using data from COPERT.

Chapter Methodological issues is divided to two sections as two completely different approaches are implemented for projections of greenhouse gas emissions from category 1.A.3 Transport and other categories under Energy sector.

2.2.1.1. Methodological issues

2.2.1.2. Energy (excluding 1.A.3 Transport)

There were three main changes in the projections preparation in the 1. Energy sector in the current submission.

Firstly, the MESSAGE model (used in 2017 and 2019) was replaced by a data-driven model structure. The MESSAGE model was relatively laborious to enter data, did not allow some important aspects of the projections data types (e.g., what should be the energy mix to slow or fast decarbonization) and could not be used in cooperation with other institutions in the Czech Republic and neighboring countries.

The second important change which is reflected in these projections is the European Green Deal, which raises decarbonisation targets and brings many new European and Czech policies and measures over the next two years and forcing an overhaul of the National System for Policies and Measures (MoE, 2015) and related system for projections.

Lastly, there was a sharp increase in the prices of emission allowances in the last three years, which makes the system less predictable. Companies are likely to adapt their strategies to the situation and significantly change their fuel demands.

Due to the above-described changes and in order to facilitate the transition from MESSAGE to TIMES (The Integrated MARKAL-EFOM System) model a data-driven model structure applying expert judgment methodologies was chosen for the current projections in the 1. Energy sector. TIMES model is planned to be further developed for the next projections in 2023. National System for Policies and Measures and the National System for Projections will be also extensively revised for the 2023 projections.

Input data

Data for electricity and heat production are provided by the Ministry of Industry and Trade (MIT), who collects data regarding future plans of energy and industrial companies, such as constructions of new sources or shutdowns, technical details, life expectancy, investment, operating costs.

MIT and Czech electricity and gas market operator (Operátor trhu s elektřinou, a.s.) (OTE) provide information about the development of energy production and consumption. The input data also correspond to the State Energy Policy (MIT, 2015).

The following activities were included in calculation of emission projections for the individual GHG:

CO_2 – combustion of fuels in fuel conversion processes (public and factory energy production), combustion of fuels for final consumption (industrial processes, transport, households, agriculture and the sector of public and commercial services), fuel improvement processes (refineries, post-mining treatment of coal and coking) and removal of SO_2 from combustion products using limestone,

CH_4 – coal mining and its post-mining treatment; natural gas mining, storage, transport and distribution; and petroleum mining, storage, transport and refinement,

N_2O – combustion of fuels in stationary sources.

For projections of categories under 1. Energy sector (except the category 1.A.3 Transport) were, aside from the predictions from MIT, taken into account the following initial assumptions:

Demographic trends – Population predictions are based on data from the Czech Statistical Office (CzSO); the number of households for energy demand calculation was provided by MIT.

Domestic coal availability - Solid fuels, especially lignite, continue to be a primary domestic energy source in the near future. These sources depend on the binding nature of territorial environmental limits on brown coal mining in accordance with the Governmental decision 827/2015, which partially reduces territorial environmental limits at the mine Bílina and keeps the current limits at the ČSA mine.

Quite dramatic development is observed in hard coal mining which became cost ineffective. The last operating mining company (OKD) shortened economically exploitable reserves and announced gradual closure of all its hard coal mines by 2025 as reflected in Tab. 2-10.

Tab. 2-10 Projections of domestic coal mining, the updated trends in the capacities of mining

Brown coal [kt] (Name of mine)	2018	2020	2025	2030	2035	2040	2045	2050
Libous	11450	12 000	10 000	10 000	6 500	0	0	0
Bilina	9450	9 600	8 500	8 500	7 000	4 500	4 500	4 500
CSA	3670	3 500	0	0	0	0	0	0
Vrsany	7770	7 500	7 500	7 500	7 500	7 500	5 500	5 500
Jiri and Druzba	6850	6 000	5 500	5 000	4 000	3 000	0	0
Centrum	0	0	0	0	0	0	0	0
Total	**39191**	**38 600**	**31 500**	**31 000**	**25 000**	**15 000**	**10 000**	**10 000**
Hard coal [kt] (Name of mine)	**2018**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
CSM	2600	2650	0	0	0	0	0	0
Karvinna - CSA	1950	1600	0	0	0	0	0	0
Karvinna - Lazy	0	0	0	0	0	0	0	0
Darkov	0	0	0	0	0	0	0	0
Paskov	0	0	0	0	0	0	0	0
Total	**4550**	**4250**	**0**	**0**	**0**	**0**	**0**	**0**

(MIT 2020)

Energy production - The energy consumption and production scenarios of the projections is in compliance with the State Energy Policy (MIT, 2015) and with National Energy and Climate Plan of the Czech Republic (MIT, 2019). The scenarios evaluated in the frame of the State Energy Policy (MIT, 2015) were based on three priorities: (1) safety, (2) sustainability and (3) competitiveness. In the State Energy Policy (MIT, 2015) are set constrains for the acceptable development of the primary energy mix and electricity generation.

The most likely energy system development scenario was used for model calculations, applying the following assumptions from the Optimized scenario of the State Energy Policy (MIT, 2015):

- Temelín nuclear power plant remains in operation for the whole period (2020 – 2050).
- The operation of the current 4 units of the Dukovany nuclear power plant will be decommissioned gradually in the period 2035 – 2037 or latest 2045-2047. New nuclear units will be introduced after 2036.
- The territorial environmental limits on brown coal/lignite mining are retained at the ČSA mine and partly reduced at the Bílina mine.

Final energy consumption

The total final energy consumption shows a slight decrease during the projected period. The main drop is predicted for coal whereas renewables consumption is expected to be growing. Also, the final consumption of electricity will increase.

Tab. 2-11 Final energy consumption

Energy source [PJ]	2020	2025	2030	2035	2040	2045	2050
Coal	59.1	45.6	37.1	29.7	27.6	25.0	23.6
Manufactured gases	12.1	11.8	11.2	11.1	11.0	10.9	10.9
Oil and petroleum products	269.0	270.9	268.2	266.1	259.9	248.8	231.0
Natural gas	224.2	217.6	206.0	205.2	203.9	201.7	199.6
Renewables and biofuels	124.0	138.6	153.1	154.5	148.8	142.3	134.7
Non-renewable waste	9.8	9.6	9.3	9.3	9.2	9.1	9.1
Derived heat	89.3	85.5	80.9	78.0	75.0	71.4	68.1
Electricity	213.8	219.3	223.8	229.1	236.7	243.4	248.5
TOTAL	**1 002.0**	**999.4**	**990.3**	**983.6**	**972.6**	**953.3**	**926.0**

(MIT, 2015)

Final energy consumption of households

In households a decline in final energy consumption is expected. The main cause of this tendency is insulation and revitalization of family, panel and other collective housing. Around 2020 starts the second insulation round due to the ending of the lifetime of insulations installed in the first round. The only subcategory expected to grow is electricity despite increasing efficiency of appliances.

Tab. 2-12 Final energy consumption of households

Energy source [PJ]	2020	2025	2030	2035	2040	2045	2050
Coal	30.0	23.7	17.3	10.7	9.8	8.8	7.9
Oil and petroleum products	1.8	1.8	1.7	1.7	1.5	1.4	1.3
Natural gas	83.3	72.9	61.7	59.3	57.2	55.2	53.0
Renewables and biofuels	75.2	84.5	93.7	94.3	88.0	81.2	74.1
Derived heat	43.1	41.7	40.4	39.0	37.6	36.1	34.5
Electricity	55.2	57.0	59.0	61.2	63.7	65.5	66.9
TOTAL	**288.5**	**281.6**	**273.9**	**266.3**	**257.9**	**248.3**	**237.7**

(MIT, 2015)

Final energy consumption of commercial sector

For commercial sector the main energy sources are natural gas, electricity and heat. The consumption of natural gas in the future strongly decreases while heat and electricity show only a slow decline (Tab. 2-18).

Tab. 2-13 Final energy consumption of commercial sector

Final energy consumption [PJ]	2020	2025	2030	2035	2040	2045	2050
Coal	1.0	0.6	0.3	0.0	0.0	0.0	0.0
Oil and petroleum products	1.0	0.9	0.8	0.6	0.4	0.2	0.0
Natural gas	45.5	42.3	38.9	35.6	32.4	29.5	27.2
Renewables and biofuels	2.6	2.7	2.8	2.9	2.9	3.0	3.0
Derived heat	18.5	17.8	17.0	16.3	15.5	14.8	14.0
Electricity	57.7	57.0	55.8	54.5	52.8	51.3	50.4
Other	1.2	1.2	1.2	1.2	1.2	1.2	1.2
TOTAL	**126.4**	**121.4**	**115.6**	**109.9**	**104.1**	**98.7**	**94.6**

(MIT, 2015)

Electricity and district heat generation

The total electricity and district heat generation from coal is decreasing and natural gas, nuclear energy and renewable energy is taking over. The first new nuclear unit is planned to be added after 2036 as partial replacement of the nuclear power plant Dukovany as mentioned above.

Tab. 2-14 Structure of charge for electricity and district heat generation

Charge for electricity and heat [PJ]	2020	2025	2030	2035	2040	2045	2050
Coal	471.6	364.2	361.7	289.8	147.9	141.9	139.2
Manufactured gases	30.5	30.6	30.4	30.0	13.1	6.9	6.9
Oil and petroleum products	1.4	1.4	1.4	1.4	1.3	1.3	1.3
Natural gas	56.7	57.4	50.9	46.8	101.7	116.2	114.9
Renewables and biofuels	67.0	76.5	89.2	100.8	110.6	113.2	115.9
Industrial waste	0.7	0.7	0.7	0.7	0.7	0.7	0.6
Municipal waste	1.8	4.9	5.8	5.8	5.8	5.8	5.8
Nuclear power plants	339.3	339.5	339.8	394.7	464.0	464.3	464.6
Derived heat	1.0	1.0	1.0	1.0	1.0	0.9	0.9
Electricity	5.7	5.7	5.7	5.7	5.7	5.7	5.8
TOTAL	**975.8**	**881.9**	**886.5**	**876.5**	**851.8**	**856.9**	**855.8**

Due to the nature of the applied data-driven model approach the outlooks from MIT (MIT, 2020) were used with the assumption that the future fuel prices (EC, 2018) and EU ETS (EC, 2018) were already accommodated.

Projected emissions for individual sectors were calculated using outlooks for the fuel mix indicators in concrete sector multiplied by the relevant emission factors (EF) and oxidation factors (OxF) from latest National Inventory Report (NIR) (CHMI, 2020). In future, changes in EFs solid fuels can be expected based on termination of mining locations in the Czech Republic. For example, calculation of the emissions from the category 1.A.1.a Public electricity and heat production included all fuels from Tab. 2-20, except fuels which are not connected with category 1.A.1.a Public electricity and heat production (Renewables and biofuels, Nuclear power plants, and the part of municipal waste, which is not solid, but renewable) and the part of Manufactured gases which is used in category 1.A.1.c Manufacture of solid fuels and other energy industries.

Projected emissions in sector 1.A.1.c Manufacture of solid fuels and other energy industries are influenced mainly by termination of operations in Vřesová steam-gas power plant in 2020 which were not part of the original outlook (Tab. 2.20). Therefore, the outlook data from Manufactured gases (i.e., GasWorksGas) was modified for the purposes of the analysis.

Three relatively less significant sectors (1.A.1.b Petroleum refining, 1.A.4.c Agriculture/forestry/fishing and 1.A.5 Other) were partly bounded with 1.A.3 Transport sector and diesel-oil and gasoline production. The sector 1.A.5 is expected decline slower than 1.A.3 Transport since 1.A.5 includes army, air force and rescue service for which slower electrification can be expected. Projected emissions in 1.A.1.b Petroleum refining were connected not only with 1.A.3 Transport, but also with other sectors (e.g., 1.A.2 and 1.A.4) in which are refining products used.

Projected emissions in 1.B Fugitive emissions from fuels are dominantly linked to projections of domestic coal mining as that is the major source of 1.B emissions.

2.2.1.3. Methodological issues – 1.A.3 Transport

Road transport shows steadily growing activity and consequently energy consumption and GHG emissions. After the year 2007, transport, especially fright transport, was hit by the economic crisis. However, the growing trend of transport activity continued also in the period 2010 – 2020.

In 2018, the total emissions from 1.A.3 Transport were 20 063.26 kt CO_2 eq. It is the increase on 183 % from in 1990. GHG emission trend from 1.A.3 Transport for 2000 to 2018 is depicted in Fig. 2-4.

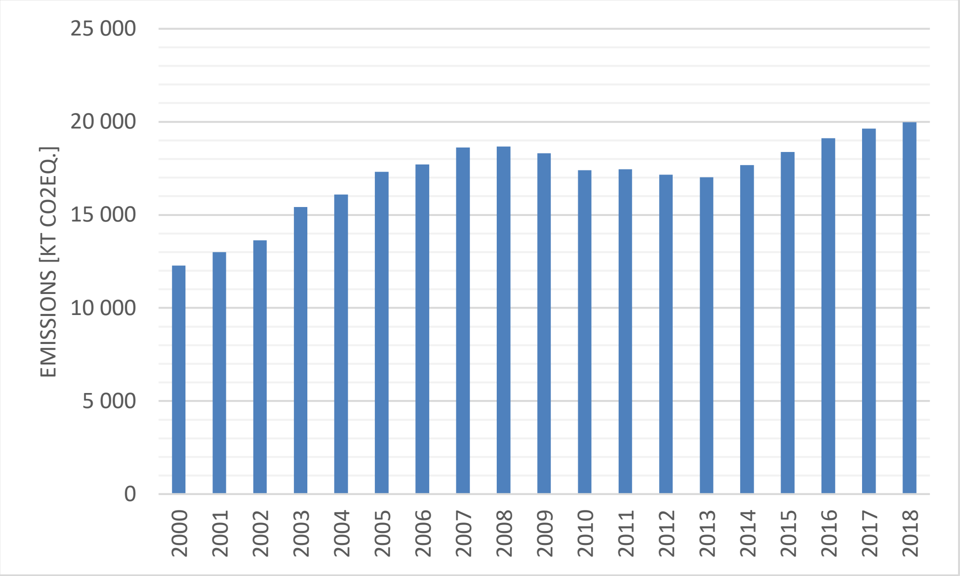


Fig. 2-4 The emission trend in 1.A.3 Transport during reporting period 2000 – 2018 (CHMI, 2020)

The projected structure of energy carriers in the 1.A.3 Transport counts with growing shares of biofuels and natural gas use. A significant increase of electric and hybrid cars is supposed to start following 2030.

The update of the projections for this reporting was based mainly on the new road transport data, which were obtained from COPERT. COPERT is the EU standard vehicle emissions calculator which uses a detailed methodology for EMEP/CORINAIR transport emissions calculations (EEA , 2016). The overall transport performance forecast and the division of transport work are based on the Transport Sector Strategy (MT, 2013). Also, non-road transport forecasts were not changed. In the field of road transport projections, the procedure was as follows:

- Aggregation of downloaded data from COPERT for the period 2000 - 2018 into less detailed categories (aggregation type - sum). COPERT has a total of 372 categories of vehicles, the projection cannot be performed for such a number of categories. Aggregation was made by transport mode, the fuel used and the EURO emission standard. The original 372 COPERT categories have been aggregated to 68 groups.
- Addition of vehicle categories with supposed use in future, which are not in COPERT now.
- Addition of non-road vehicle categories.
- Including these additions, the model has in total 91 vehicle categories.
- Calculation of annual vehicle kilometres (2000 – 2018), from fleet and mileage data.
- Updating data on new registrations and discarded vehicles.

- Distribution of future vehicle kilometres from older vehicle categories (2019 – 2050), so that their number is continuously falling to zero as part of ongoing fleet renewal.
- Input of official transport prognosis data (from Transport Sectoral Strategy (MT, 2013)) to emissions projections model.
- Calculation of future vehicle kilometres from new vehicles for each year (2019 - 2050), based on the difference between total prognosis data (from Transport Sectoral Strategy (MT, 2013)) and sums of performance of older vehicles.
- Input of official energy consumption prognosis data (from Czech Ministry of Industry and Trade).
- Splitting of future vehicle kilometres from new vehicles by fuel, with a help of mentioned energy consumption prognosis data.
- Export of implied emission factors from the COPERT program and their appropriate distribution for vehicle categorization in the projection model.
- Calculation of projected emissions, multiplying outputs and emission factors.
- Expression of GHG emissions as CO2 equivalent, based on the global warming potential of CH4 and N2O.
- Calculation of supposed emissions reductions by individual Policies and Measures (PaM), their aggregation to With existing measures (WEM) and With additional measures (WAM) scenarios and calculation of GHG emissions in WEM and WAM scenarios.

With regards to emission reductions by the application of individual policies and measures (for more details please see chapter 0, only quantifiable measures have been calculated. Calculable measures are described in following table (2-15).

Tab. 2-159 Overview of PaMs with estimated emission reductions

PaM title	Changes in the prediction model
Support of biofuels	CO_2 emission factors resulting from an increased share of biofuels.
Regulation on CO_2 from cars	Modification of new cars activity data in order to have its weighted average equal to 95 g/km.
Regulation on CO_2 from vans	Modification of new cars activity data in order to have its weighted average equal to 147 g/km.
ICAO agreement (International Civil Aviation Org.)	No changes from the previous projections (2019).
Modal shift	Reduced road freight transport performance with an estimated share of trips longer than 300 km, of which 30 % should be shifted to rail.
Economical and tax tools	Change in prospective energy consumption where environmentally friendly fuel predominates, which should be less taxed.
Road toll	There is a change in the demand for road freight transport, based on price-demand dependency.
Further reduction of CO_2 emissions	Modification of new cars and light duty vehicles activity data in order to achieve required decrease of CO_2 emissions in 2025 and 2030.

2.2.1.4. Projected greenhouse gas emissions 'With existing measures (WEM) scenario' and 'With additional measures (WAM) scenario'

According to the projections of GHG emissions in 1. Energy sector it is expected that emissions are going to decrease for both scenarios. Decrease of emissions is more visible for WAM scenario which includes additional measures for category 1.A.1 Energy industries, 1.A.2 Manufacturing Industries and construction, 1.A.3 Transport and 1.A.4 Other sectors. For 2050, the difference between WEM and WAM scenario is calculated as 11.71 Mt CO_2 eq.

In total numbers it is expected that GHG emissions from 1. Energy sector will decrease approximately by 65% in 2050 compared to 1990, by 54% compared to 2005 and by 42% compared to current level (2018) of emissions for WEM scenario. It is projected, that GHG emissions will decrease in WAM scenario approximately by 72% in 2050 compared to 1990, by 62% compared to 2005 and 53% compared to current level (2018).

Tab. 2-16 Reported and projected emissions of GHG in 1. Energy sector – WEM and WAM scenarios

[Mt CO_2 eq.]	Reported emissions			Projected emissions					Difference [%]		
	1990	**2005**	**2018**	**2020**	**2025**	**2030**	**2040**	**2050**	**1990 – 2030**	**1990 – 2040**	**1990 – 2050**
WEM	161.32	120.60	96.88	97.35	83.91	80.62	57.64	55.78	-50.03	-64.27	-65.43
WAM	161.32	120.60	96.88	96.97	74.73	57.76	38.81	36.70	-64.19	-75.94	-77.25

2.2.1.5. Projected greenhouse gas emissions 'With existing measures (WEM) scenario'

The 1. Energy sector is source of CO2, CH4 and N2O emissions. It is expected that emissions are going to decrease for all gases emitted by 1. Energy sector during projected period. It is expected that in 2050 CO2 emissions will decrease by 42%, CH4 by 62% and N2O by 38% compared to current level (2018) of emissions.

Tab. 2-17 Breakdown of reported and projected emissions of GHG by gases - WEM scenario

[Mt CO_2 eq.]	Reported emissions			Projected emissions							Difference [%]			
	1990	**2005**	**2018**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**	**1990 – 2020**	**1990 – 2030**	**1990 – 2040**	**1990 - 2050**
CO_2	147.26	112.87	92.01	92.72	80.65	77.48	68.46	55.29	54.71	53.74	-37.04	-47.39	-62.45	-63.51
CH_4	13.24	6.92	4.22	4.00	2.71	2.61	2.32	1.92	1.69	1.64	-69.75	-80.32	-85.47	-87.64
N_2O	0.83	0.81	0.65	0.62	0.56	0.54	0.49	0.42	0.41	0.40	-25.07	-35.25	-48.85	-52.08
Total	**161.32**	**120.60**	**96.88**	**97.35**	**83.91**	**80.62**	**71.27**	**57.64**	**56.81**	**55.78**	**-39.66**	**-50.03**	**-64.27**	**-65.43**

In 2018 the dominant GHG source in the 1. Energy sector was category 1.A.1 Energy industries (53%), followed by 1.A.3 Transport (21%), 1.A.4 Other Sectors (14%) and 1.A.2 Manufacturing industries (10%). Emissions from category 1.B Fugitive emissions from fuels has 3% share on total emissions from 1. Energy sector. A significant reduction of GHG emissions can be observed in 1.A.2 Manufacturing industries (81%) and 1.A.4 Other Sectors (61%) during the past three decades (1990 - 2018), mainly due to transition from domestic coal to other fuels, in particular natural gas. Similar tendency can be assumed in 1.A.1 Energy industries, as easily accessible domestic reserves of brown coal are getting close to depletion.

For the vast majority of categories under 1. Energy sector is expected that emissions will decrease in 2050 compared to the current level of emissions. For category 1.A.1 Energy Industries, which has major share on total GHG emissions from 1. Energy, it is expected that emissions will decrease in 2050 compared to current level of emissions by 55%.

The emission trend in category 1.A.1 Energy industries is mainly driven by the category 1.A.1.a Public electricity and heat production and shows a decrease after the year 2020. This change in electricity generation is partly result of the depleting reserves of domestic lignite. Some power plants closed or will close soon (e.g., Melnik II, Ledvice II and Prunerov I). In the period between 1990 and 2050 a drop of 59%

is projected in the category 1.A.1 Energy industries. In the category 1.A.1.a Public electricity and heat production the decline is even bigger – approximately 62%. Construction of new nuclear units is expected after the year 2036. The decrease of GHG emissions is also caused by the increased share of RES (Renewable Energy Sources) in electricity and heat generation.

The projected emissions in category 1.A.2 Manufacturing industries and construction are slightly decreasing. The drop of GHG emission in this sector is 79% in the period 1990 – 2020 and 81% in the period 1990 – 2050.

In the category 1.A.4 Other sectors drop up to 78% in 2050 compared to 1990 is expected to be achieved. In the 1.A.4.a commercial sector even a drop up to 80% will be reached if all existing measures will be applied. The highest emission share (> 50%) in 1.A.4 Other sectors is from the category 1.A.4.b Residential.

The projected decline of 1.B Fugitive emissions from fuels results mainly from decreasing mining of hard and brown coal and includes methane leakages from deep and open coal mines, crude oil mining and cracking, natural gas leakages from mining, transmission and distribution of natural gas and natural gas leakages from power plants and heating plants.

Tab. 2-18 Breakdown of reported and projected emissions of GHG by categories in Energy – WEM scenario

[Mt CO_2 eq.]	Reported emissions			Projected emissions						Difference [%]			
	1990	2005	2018	2020	2025	2030	2035	2040	2045	2050	1990-2020	1990-2030	1990-2040	1990-2050
1. Energy	**161.32**	**120.60**	**96.88**	**97.35**	**83.91**	**80.62**	**71.27**	**57.64**	**56.81**	**55.78**	**-39.66**	**-50.03**	**-64.27**	**-65.43**
A. Fuel combustion (sectoral approach)	**149.45**	**114.19**	**93.55**	**94.13**	**82.01**	**78.80**	**69.71**	**56.48**	**55.86**	**54.86**	**-37.03**	**-47.28**	**-62.22**	**-63.30**
1. Energy industries	56.86	63.17	51.07	53.17	44.78	44.04	35.96	23.48	23.59	23.17	-6.60	-22.62	-58.75	-59.30
a. Public electricity and heat production	54.84	56.48	44.78	47.47	40.72	40.12	32.57	21.00	21.13	20.78	-13.53	-26.93	-61.75	-62.15
b. Petroleum refining	0.49	0.89	0.51	0.48	0.44	0.42	0.42	0.41	0.41	0.40	-1.80	-13.72	-16.52	-18.24
c. Manufacture of solid fuels and other energy industries	1.52	5.79	5.79	5.21	3.62	3.51	2.98	2.08	2.06	1.99	242.96	131.01	36.86	31.24
2. Manufacturing industries and construction	47.11	18.84	9.96	9.98	9.78	9.58	9.38	9.18	8.98	8.78	-78.82	-79.67	-80.52	-81.36
3. Transport	11.48	17.36	19.06	18.27	16.26	15.43	15.53	15.32	15.16	15.13	150.8	111.8	110.3	107.68
a. Domestic Aviation	0.14	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	-93.46	-95.75	-97.22	-98.16
b. Road Transportation	6.35	16.7	18.64	17.86	15.87	15.06	15.19	14.99	14.85	14.84	181.21	137.23	136.13	133.66
c. Railways	0.73	0.32	0.32	0.31	0.29	0.27	0.25	0.23	0.21	0.20	-57.77	-63.62	-68.64	-72.97
d. Domestic Navigation	0.06	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	-83.16	-86.92	-89.85	-92.12
e. Other Transportation	0.01	0.07	0.80	0.08	0.08	0.09	0.09	0.09	0.09	0.09	744.8	753.26	761.81	761.81
4. Other sectors	33.81	14.55	13.15	12.41	10.90	9.46	8.55	8.21	7.85	7.49	-63.54	-72.21	-75.89	-78.00
a.Commercial/institutional	9.96	3.53	2.79	2.74	2.60	2.47	2.35	2.24	2.13	2.02	-72.85	-75.45	-77.79	-79.92
b. Residential	19.91	9.68	9.12	8.52	7.23	5.93	5.12	4.92	4.67	4.42	-57.42	-70.35	-75.43	-77.92
c.Agriculture/forestry/fishing	3.95	1.34	1.24	1.15	1.05	1.01	1.01	1.00	1.00	0.99	-70.94	-74.45	-74.60	-74.87
5. Other	0.19	0.27	0.32	0.31	0.30	0.29	0.29	0.29	0.29	0.29	NA	NA	NA	NA
B. Fugitive emissions from fuels	**11.86**	**6.41**	**3.32**	**3.22**	**1.90**	**1.82**	**1.56**	**1.16**	**0.95**	**0.92**	**-72.88**	**-84.68**	**-90.22**	**-92.25**
1. Solid fuels	10.78	5.51	2.71	2.59	1.32	1.30	1.07	0.70	0.51	0.51	-75.95	-87.95	-93.55	-95.30
2. Oil and natural gas and other emissions from energy production	1.08	0.9	0.61	0.62	0.57	0.51	0.49	0.46	0.43	0.41	-42.87	-52.56	-57.54	-62.41
C. CO_2 transport and storage	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**

2.2.1.6. 'With additional measures (WAM) scenario'

Additional measures in 1. Energy sector are applicable for projections of GHG emissions from category 1.A.1 Energy industries, 1.A.2 Manufacturing Industries and construction, 1.A.3 Transport and 1.A.4 Other sectors. This chapter is divided into two sections as two completely different approaches are implemented for projections of GHG emissions from 1.A.3 Transport and the rest of the categories under 1. Energy sector.

WAM for 1.A.1 Energy industries and 1.A.4 Other sectors

Additional policies and measures (PaM), i.e. (1) Energy efficiency measures in industry sector, (2) Soft energy efficiency measures, (3) Energy efficiency measures in residential sector and (4) Energy efficiency measures in commercial and institutional sector are focusing on reduction of CO2. Modernisation fund is focusing on reduction on CO2 and CH4. According to the projected WAM scenario, emissions from 1. Energy (excluding 1.A.3 Transport) should decrease by 83%by 2050 compared to 2018. The GHG emissions from 1. Energy excluding Transport are expected to decline in both scenarios WEM and WAM from 2020 to 2050 (Tab. 2-19). The emission projected in WAM scenario for 1. Energy (excluding 1.A.3 Transport) is 14.6 Mt CO2 eq. lower than WEM scenario by 2050.

Tab. 2-19 Reported and projected emissions of GHG in Energy excluding 1.A.3 Transport – WEM and WAM scenario

	Reported emissions [Mt CO_2 eq.]			Projected emissions [Mt CO_2 eq.]							Difference [%]			
	1990	2005	2018	2020	2025	2030	2035	2040	2045	2050	1990 – 2020	1990 – 2030	1990 – 2040	1990 – 2050
WEM	149.83	103.24	76.82	79.08	67.65	65.19	55.74	42.32	41.65	40.65	-48.67	-57.69	-72.53	-73.61
WAM	149.83	103.24	76.82	79.08	61.32	47.74	40.61	29.72	29.05	26.05	-48.67	-69.03	-80.71	-83.09

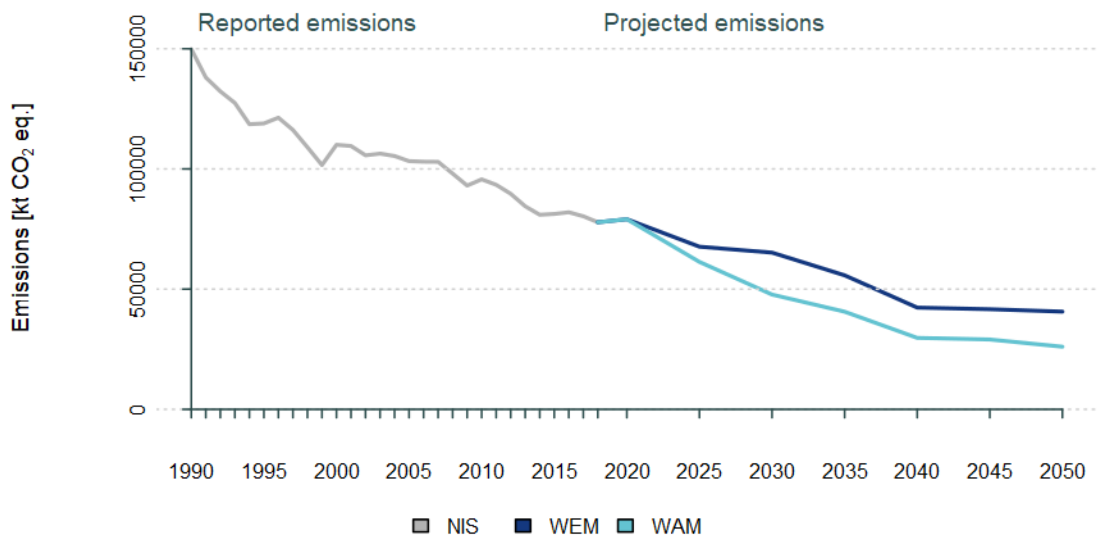


Fig. 2-5 Reported and projected emissions of GHG in 1. Energy (excluding 1.A.3 Transport) – WEM, WAM scenario

Tab. 2-20 Breakdown of reported and projected emissions of GHG by concerned categories in 1. Energy (excluding 1.A.3 Transport) - WAM scenario

[Mt CO_2 eq.]	Reported emissions			Projected emissions							Difference [%]			
	1990	2005	2018	2020	2025	2030	2035	2040	2045	2050	1990 – 2020	1990 – 2030	1990 – 2040	1990 – 2050
1.A.1.a Public electricity and heat production	54.84	56.48	44.78	47.47	37.93	29.59	24.16	14.79	14.92	14.57	-13.53	-46.06	-73.03	-73.42
1.A.1.c Manufacture of solid fuels and other energy industries	1.52	5.79	5.79	5.21	3.53	3.34	2.81	1.94	1.92	1.86	242.96	119.48	27.73	22.11
1.A.2 Manufacturing industries and construction	47.11	18.84	9.96	9.98	8.42	5.88	5.73	5.63	5.43	5.23	-78.82	-87.52	-88.04	-88.90
1.A.4.a Commercial/ institutional	9.96	3.53	2.79	2.74	2.26	1.82	1.74	1.68	1.57	1.47	-72.85	-81.96	-83.33	-85.45
1.A.4.b Residential	20.01	9.68	9.12	8.52	5.48	3.53	2.82	2.77	2.52	2.27	-57.42	-82.27	-86.09	-88.60

WAM for 1.A.3 Transport

Only difference between WEM and WAM scenario in Energy sector is in additional measures used for projections of GHG emissions from category 1.A.3 Transport. Following chapter will describe category 1.A.3 in more detail with focus on difference between WEM and WAM scenario.

The GHG emissions from transport are expected to decline in both scenarios WEM and WAM from 2020 (Tab. 2-101 and Fig. 2-66). This results from fuel switches in favour of fuels with lower carbon content, from obligatory improved energy efficiency of new personal cars and especially from a higher share of electric and hybrid vehicles. Due to reduction measures the decrease of CO_2 emissions is supposed to 2040. The main efficiency has the application of CO_2 regulation of cars and vans and also the support of biofuels.

Tab. 2-101 Reported and projected emissions of GHG in 1.A.3 Transport – WEM and WAM scenarios

[Mt CO_2 eq.]	Reported emissions			Projected emissions							Difference [%]			
	1990	2005	2018	2020	2025	2030	2035	2040	2045	2050	1990 – 2020	1990 – 2030	1990 – 2040	1990 – 2050
WEM	11.48	17.36	19.06	18.27	16.26	15.43	15.53	15.32	15.16	15.13	150.79	111.80	110.30	107.68
WAM	11.48	17.36	19.06	17.95	13.47	10.08	9.64	9.16	8.79	8.71	146.47	38.40	25.72	19.62

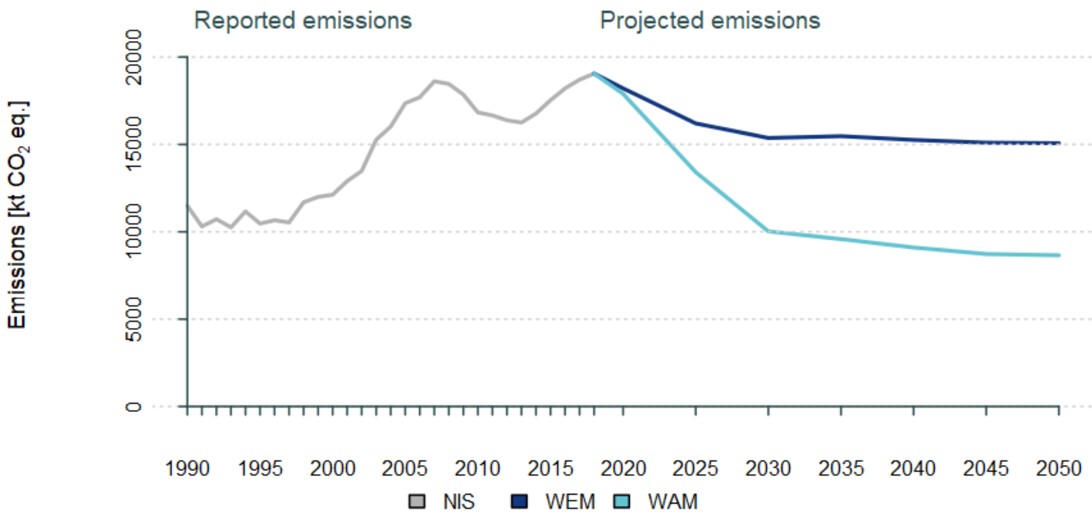


Fig. 2-6 Reported and projected emissions of GHG in 1.A.3 Transport – WEM, WAM scenario

Following tables contain breakdown of reported and projected emissions by gases and by categories for WEM scenario. According to the WEM scenario, emissions from 1.A.3 Transport should decrease by 24% in 2040 compared to 2018.

Tab. 2-112 Breakdown of reported and projected emissions of GHG by gases in 1.A.3 Transport - WEM scenario

[Mt CO_2 eq.]	Reported emissions			Projected emissions							Difference [%]			
	1990	**2005**	**2018**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**	**1990 – 2020**	**1990 – 2030**	**1990 – 2040**	**1990 – 2050**
CO_2	11.22	17.10	18.82	18.07	16.08	15.26	15.37	15.16	15.00	14.97	156.92	117.05	115.60	112.94
CH_4	0.08	0.06	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.04	-42.33	-44.32	-28.86	-5.45
N_2O	0.19	0.20	0.20	0.18	0.16	0.14	0.14	0.13	0.12	0.12	-15.93	-32.73	-39.06	-45.16
Total	**11.48**	**17.36**	**19.06**	**18.27**	**16.26**	**15.43**	**15.53**	**15.32**	**15.16**	**15.13**	**150.79**	**111.80**	**110.30**	**107.68**

Tab. 2-212 Breakdown of reported and projected emissions of GHG by categories in 1.A.3 Transport - WEM scenario

[Mt CO_2 eq.]	Reported emissions			Projected emissions						Difference [%]			
	1990	**2005**	**2018**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**	**1990 – 2020**	**1990 – 2030**	**1990 – 2040**	**1990 – 2050**
1.A.3.a Domestic Aviation	0.14	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	-93.46	-95.75	-97.22	-98.16
1.A.3.b Road Transportation	10.43	16.95	18.64	17.86	15.87	15.06	15.19	14.99	14.85	14.84	181.21	137.23	136.13	133.66
1.A.3.c Railways	0.86	0.32	0.32	0.31	0.29	0.27	0.25	0.23	0.21	0.20	-57.77	-63.62	-68.64	-72.97
1.A.3.d Domestic Navigation	0.05	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	-83.16	-86.92	-89.85	-92.12
1.A.3.e Other Transportation	0.01	0.07	0.08	0.08	0.08	0.09	0.09	0.09	0.09	0.09	744.80	753.26	761.81	761.81
Total	**11.48**	**17.36**	**19.06**	**18.27**	**16.26**	**15.43**	**15.53**	**15.32**	**15.16**	**15.13**	**150.80**	**111.80**	**110.30**	**107.68**

It is projected, that additional measures *Economic tax tools, Road toll* and mainly *Further decrease of CO_2 emissions in 2025 and 2030* will influence GHG emissions from 1.A.3 Transport as it is shown in following tables. Description of the measures is specified in Chapter 1.2.3. According to the WAM scenario, emissions from 1.A.3 Transport should decrease by 55% in 2040 compared to 2018.

Tab. 2-2413 Breakdown of reported and projected emissions of GHG by gases in 1.A.3 Transport - WAM scenario

[Mt CO_2 eq.]	Reported emissions			Projected emissions						Difference [%]			
	1990	**2005**	**2018**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**	**1990 – 2020**	**1990 – 2030**	**1990 – 2040**	**1990 – 2050**
CO_2	11.22	17.10	18.84	17.75	13.31	9.96	9.52	9.05	8.68	8.61	152.49	41.58	28.66	22.43
CH_4	0.08	0.06	0.02	0.02	0.02	0.01	0.01	0.02	0.02	0.02	-42.61	-65.84	-59.99	-44.87
N_2O	0.19	0.20	0.20	0.18	0.14	0.11	0.10	0.10	0.09	0.08	-17.42	-47.64	-55.33	-61.21
Total	**11.48**	**17.36**	**19.06**	**17.95**	**13.47**	**10.08**	**9.64**	**9.16**	**8.79**	**8.71**	**146.47**	**38.40**	**25.72**	**19.62**

Tab. 2-2514 Breakdown of reported and projected emissions of GHG by categories in transport - WAM scenario

[Mt CO_2 eq.]	Reported emissions			Projected emissions							Difference [%]			
	1990	2005	2018	2020	2025	2030	2035	2040	2045	2050	1990 – 2020	1990 – 2030	1990 – 2040	1990 – 2050
1.A.3.a Domestic Aviation	0.14	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	-93.46	-95.75	-97.22	-98.16
1.A.3.b Road Transportation	10.43	16.95	18.64	17.54	13.08	9.72	9.30	8.83	8.48	8.42	176.25	53.02	39.11	32.64
1.A.3.c Railways	0.86	0.32	0.32	0.31	0.29	0.27	0.25	0.23	0.21	0.20	-57.77	-63.62	-68.64	-72.97
1.A.3.d Domestic Navigation	0.05	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	-83.16	-86.92	-89.85	-92.12
1.A.3.e Other Transportation	0.01	0.07	0.08	0.08	0.08	0.09	0.09	0.09	0.09	0.09	744.80	753.26	761.81	761.81
Total	**11.48**	**17.36**	**19.06**	**17.95**	**13.47**	**10.08**	**9.64**	**9.16**	**8.79**	**8.71**	**146.47**	**38.40**	**25.72**	**19.62**

2.2.5 Sensitivity analysis

2.2.5.1 Sensitivity analysis of 1. Energy (excluding) 1.A.3 Transport

Projections of greenhouse gas emissions from 1. Energy (excluding 1.A.3 Transport) are based on input activity data. The basis of input activity data is that an increase / decrease of indicators from the input data by 5% causes an increase / decrease by 5% also in the projected emissions of the given sector.

Concrete example of the sensitivity analysis for category 1.A.1.a Public electricity and heat production is depicted in Tab. 2-26.

Tab. 2-26 Sensitivity analysis of 1.A.1.a Public electricity and heat production on input activity data (WEM scenario)

[Mt CO_2 eq.]	2020	2025	2030	2035	2040	2045	2050
WEM	47.47	40.72	40.12	32.57	21.00	21.13	20.78
WEM +5%	49.85	42.75	42.12	34.20	22.05	22.18	21.82
WEM -5%	45.10	38.68	38.11	30.95	19.95	20.07	19.74

2.2.5.2 Sensitivity analysis of 1.A.3 Transport

The sensitivity analysis for 1.A.3 Transport was done with a help of the Monte Carlo method that relies on repeated random sampling to obtain numerical results. Essential idea of the Monte Carlo method is using randomness to solve problems that might be deterministic in principle. The method is often used in physical and mathematical problems and is the most useful in the cases when it is difficult or impossible to use other approaches. From the methods of Monte Carlo, the probability density function was preferred.

2.2.6 Difference between previously and currently reported projections

There are some significant changes in projections of GHG emissions from the 1. Energy sector compared to the previous projections. These changes were mentioned in the section 2.2.1 Methodological issues. The biggest change is that we stopped using model MESSAGE and used data-driven model structure instead.

Projections for category 1.A.3 Transport were calculated in R-project unlike previous projections (2019). In road transport, COPERT time series from 2000 to 2018 were used for emissions projections. COPERT data are very detailed and need to be aggregated and processed in various ways. Also, the projections are more closely related to the prediction of energy consumption in the fleet area, with the newly registered vehicles being assigned categories respecting the expected development of fuel consumption. Emission factors used for projections are available from the COPERT database, which is generally recognized as very reliable data source.

2.3.Industrial Processes and Other Product Use

For consistency with greenhouse gas (GHG) emission inventory, the sector 2. Industrial processes and other product use (IPPU) category includes only emissions from technological processes and not from the fuel combustion used to supply energy for carrying out these processes (CHMI, 2020).

In 2018, the total aggregate GHG emissions from 2. IPPU were 16,197.51 kt of CO_2 eq., which represent increase of 4% compared to the previous year. Emissions decreased by 5% compared to the base year 1990. The major share of CO_2 emissions in this sector comes from subcategories 2.C.1 Iron and steel production, 2.F.1 Refrigeration and air conditioning and 2.A Mineral industry. N_2O emissions coming from 2.B Chemical industry are less significant (CHMI, 2020).

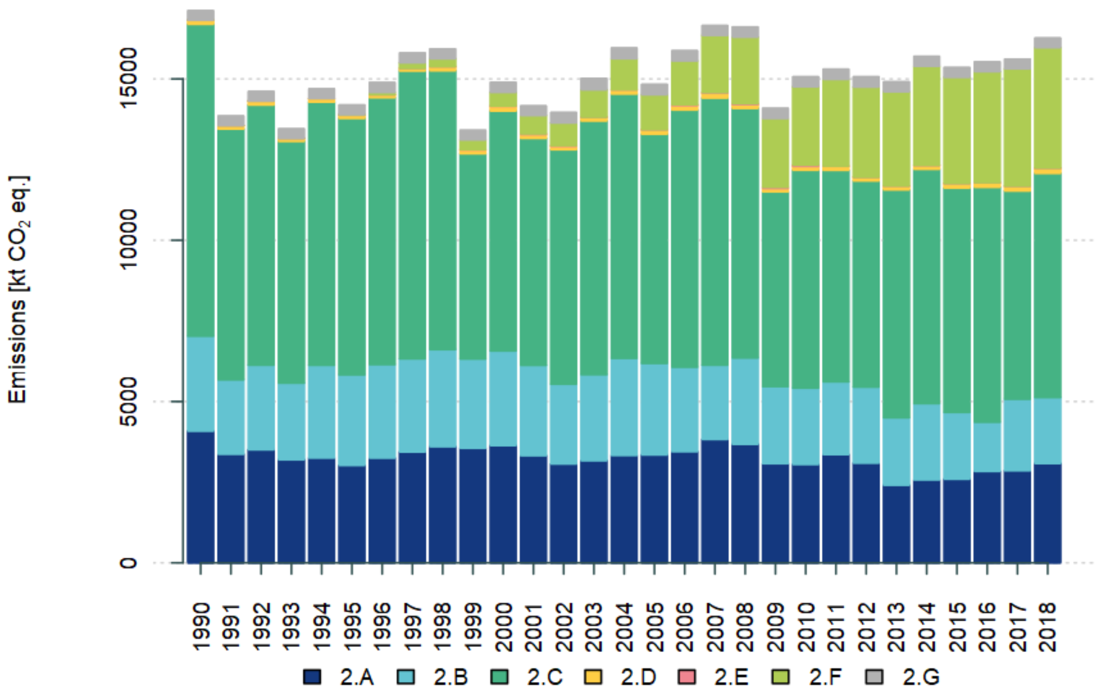


Fig. 2-7 The emission trend in 2. IPPU sector during reporting period 1990 - 2018 (CHMI, 2020)

Tab. 2-27 The emission trend in 2. IPPU sector during reporting period 1990 - 2018 (CHMI, 2020)

[kt CO_2 eq.]	2.A	2.B	2.C	2.D	2.E	2.F	2.G
1990	4082.45	2944.23	9670.32	125.56	NO	NO	290.46
1991	3365.96	2309.40	7772.69	109.65	NO	NO	290.29
1992	3506.00	2624.79	8061.10	126.15	NO	NO	291.62
1993	3195.85	2377.59	7492.05	93.14	NO	NO	292.78
1994	3249.88	2876.44	8156.27	113.77	NO	NO	293.88
1995	3019.09	2808.20	7949.20	103.75	NO	13.82	294.90
1996	3247.34	2898.00	8274.80	90.19	NO	71.53	304.52
1997	3435.56	2889.09	8923.66	76.63	1.14	174.45	302.32

1998	3599.41	3013.42	8643.19	125.73	1.14	242.98	301.19
1999	3553.49	2766.38	6363.17	120.32	8.51	300.15	294.14
2000	3633.37	2937.08	7435.43	146.75	11.17	420.20	306.04
2001	3322.41	2801.75	7034.85	118.26	21.03	570.22	290.39
2002	3064.16	2475.77	7269.11	104.37	20.32	702.82	320.06
2003	3165.55	2667.40	7864.07	112.52	4.87	851.02	347.88
2004	3330.41	3010.08	8194.75	128.29	4.36	961.17	326.61
2005	3345.75	2837.88	7103.10	133.66	6.64	1083.26	316.93
2006	3445.51	2620.55	7974.50	137.34	22.03	1360.14	310.54
2007	3826.59	2303.90	8278.27	149.91	19.68	1774.22	299.55
2008	3674.72	2678.89	7734.59	114.96	28.94	2064.28	311.27
2009	3075.56	2388.65	6039.08	102.77	35.50	2132.35	311.88
2010	3048.42	2371.07	6752.62	115.27	41.95	2429.17	304.69
2011	3356.80	2255.64	6555.86	125.51	6.69	2688.43	309.89
2012	3092.40	2356.99	6391.24	108.17	4.12	2797.41	314.14
2013	2404.70	2093.78	7064.74	115.00	3.93	2921.49	304.29
2014	2569.79	2367.20	7265.37	113.51	4.20	3074.78	302.04
2015	2594.89	2070.59	6952.50	136.33	5.30	3291.42	299.04
2016	2 834.25	1 527.23	7 281.69	136.39	6.39	3 441.65	298.31
2017	2 855.65	2 216.61	6 456.40	141.74	7.13	3 638.72	294.37
2018	3 077.63	2 047.56	6 948.64	154.48	6.64	3 736.79	291.13

2.3.1.1. Methodological issues

The projections of GHG emissions in 2. IPPU are based on data and methodology used for inventory emission estimates reported in National Inventory Report (NIR) (CHMI, 2020).

The projections are estimated separately for each subcategory under 2. IPPU sector and also for each GHG. In the Czech Republic, there is no additional measure for 2. IPPU sector and thus only scenario With existing measures (WEM) is calculated.

The projections are implemented directly to the calculation sheets used for inventory emission estimates to NIR (CHMI, 2020). This approach allows using country specific emission factors (EF) and the same or slightly modified methodology where appropriate. For example, in cases where Tier 3 methodology is used, data are not projected for each producer/facility but rather for a group of producers/facilities.

First are the projected activity data and EFs, which are then used for projection of the entire period 2019 - 2050.

Projection of activity data:

For most of the subcategories under 2.A Mineral production, 2.B Chemical production and 2.C.1 Iron and steel production, the activity data were forecasted by the Ministry of Industry and Trade (MIT, 2020) for 2019 - 2050. The activity data for 2.C.2 - 2.C.7 were projected using statistical methods (see Tab. 2-28) by experts from the Czech Hydrometeorological Institute (CHMI); however, the emissions are under the threshold of significance (0.05%) for the whole time series (1990 – 2050). For category

2.D Non-energy products from fuels and solvent use the activity data were projected (see Tab. 2-28) by experts from CHMI.

There is no official forecasts of the fluorinated GHG (F-gases) consumption for 2.E Electronics industry, 2.F Substitutes for ozone depleting substances and 2.G Other product manufacture and use. Thus, the activity data is based on expert judgement at CHMI, strictly following Regulation No 517/2014, Directive 2006/40/EC and Kigali Amendment of the Montreal Protocol. Correlation of F-gases consumption with GDP or number of inhabitants is also investigated for better accuracy of activity data projections.

Source of activity data used for projections for each subcategory under 2. IPPU is summarized in Tab. 2-28.

Projection of EFs:

Emission projections are based on the same approaches as in NIR (CHMI, 2020), which follows the IPCC 2006 Guidelines (Gl.) (IPCC, 2006). In most cases, projections of EFs are based on values of EFs in previous years. EFs used for projections are derived as an average of EFs for selected period or EFs are calculated by forecasting methods (Tab. 2-28). Where default EFs are used for inventory emission estimates in NIR, there is the same approach applied for projections (mainly for Tier 1 methodology and F-gases inventory emission estimates).

Detailed information about EFs used for projections in subcategories under 2. IPPU is described in Tab. 2-28.

Projection of emissions:

Final projections for selected subcategory under 2. IPPU are calculated by using projected activity data and EFs. The approach is in line with IPCC 2006 Gl. (IPCC, 2006). For example, projections for category 2.F.1 Refrigeration and air conditioning equipment are calculated by model Phoenix, which is used in NIR (Ondrusova & Krtkova, 2018(1)) (CHMI, 2020). Methodology used for projections is Tier 2a, following the inventory emission estimates in NIR (CHMI, 2020) (IPCC, 2006).

Tab. 2-28 Detailed information about methodology assumptions used for projections of (sub-)categories under 2. IPPU

Projections 2019 – 2050			
Category	**Activity data**	**Emission factors**	**Methodology**
2.A Mineral Production			
2.A.1 Cement production	MIT data	Average for 2007 - 2018	Modified Tier 3
2.A.2 Lime production	MIT data	Average for 2014 - 2018	Modified Tier 3
2.A.3 Glass production	to 2030 from MIT, to 2050 derived from MIT data	Average for 2010 - 2018	Modified Tier 3
2.A.4.a Brick and ceramics	Trend of data obtained from MIT was applied on data from NIR	Average for 2015 - 2018	Modified Tier 3
2.A.4.b Soda ash production	Average production from 2012 to 2018	Plant specific	Modified Tier 3
2.A.4.d Mineral wool production, flue-gas desulphurisation and denitrification	Mineral wool - Average production from 2014 to 2018 Desulphurisation – based on trends in coal power plants Denitrification - Average consumption from 2017 to 2018	Mineral wool – Default Desulphurisation – plant specific Denitrification – average for 2017 - 2018	Tier 1 for mineral wool production, Modified Tier 3 for desulphurisation and denitrification

Projections 2019 – 2050			
Category	**Activity data**	**Emission factors**	**Methodology**
2.B Chemical Production			
2.B.1 Ammonia production	to 2030 from MIT, to 2050 derived from MIT data	Default	Tier 1
2.B.2 Nitric acid production	to 2030 from MIT, to 2050 derived from MIT data	Average for 2010 - 2016	Modified Tier 3
2.B.4.a Caprolactam	Constant production	Default	Tier 1
2.B.8.b Ethylene	to 2030 from MIT, to 2050 derived from MIT data	Default	Tier 1
2.B.8.c Vinyl chloride monomer	to 2030 from MIT, to 2050 derived from MIT data	Default	Tier 1
2.B.8.f Carbon black	Average consumption from 2014 to 2016	Default	Tier 1
2.B.8.g Styrene	Average consumption from 2010 to 2016	Plant specific, Default	Modified Tier 3, Tier 1
2.B.10 Other non-energy use in chemical industry	Average consumption from 2010 to 2018	Default, country specific	Tier 1
2.C Iron and Steel Production			
2.C.1 Iron and steel production	to 2050 from MIT	Default, country specific, plant specific	Tier 2
2.C.2 Ferroalloys production	Average consumption from 2012 to 2018	Default	Tier 1
2.C.5 Lead production	Average consumption from 2012 to 2018	Default	Tier 1
2.C.6 Zinc production	Average consumption fomr 2012 to 2018	Default	Tier 1
2.D Non-energy products from fuels and solvent use			
2.D.1 Lubricant use	Average consumption from 2012 to 2018	Default	Tier 1
2.D.2 Paraffin wax use	Average consumption from2012 to 2018	Default	Tier 1
2.D.3 Other	Average consumption from2012 to 2018	Default	Tier 1
2.E Electronics Industry			
2.E.1 Integrated circuit or semiconductor	SF_6 – projections of consumption are based on correlation with GDP NF_3 – projections of consumption are based on correlation with GDP	Default	Tier 2a
2.F Product uses as substitutes for ODS			
2.F.1 Refrigeration and air conditioning	Projections of consumption are based on previous trends (Regulation No 517/2014), and Kigali Amendment of the Montreal Protocol For 2.F.1.e, vehicle fleet projections are based on correlation with population,	Country specific and default	Tier 2a Model Phoenix was used for projections of subcategories under 2.F.1, except 2.F.1.e, where country specific approach was applied following NIR (CHMI 2020)

Projections 2019 – 2050			
Category	**Activity data**	**Emission factors**	**Methodology**
	MIT data, Directive 2006/40/EC		
2.F.2 Foam blowing agents to 2.F.5 Solvents	Projections of consumption are based on previous trends or average consumption,Regulation No 517/2014, and Kigali Amendment of the Montreal Protocol	Default	Tier 1a
2.G Other product manufacture and use			
2.G.1 Electrical equipment	Average consumption from 2017 to 2018	Default	Tier 1
2.G.2 SF_6 and PFCs from other product use	Projections of consumption based on previous trend	Default	Default
2.G.3 N_2O from product uses	Constant consumption	Default	Default

(CHMI 2020, IPCC 2006, MIT 2020)

2.3.1.2. Projected greenhouse gas emissions 'With existing measures (WEM) scenario' and 'With additional measures (WAM) scenario'

The WEM scenario includes policies and measures which affect consumption of F-gases. Those policies and measures are described in Chapter 1.3. There is no additional measure for 2. IPPU sector and thus only WEM scenario is calculated.

According to WEM scenario, total emissions from 2. IPPU will be stagnant in next few years and then slightly decreasing. It is not expected that the production capacity for main products, such as lime, cement, ammonia, iron and steel is going to decrease rapidly in the Czech Republic. The expectation is rather that the decrease of GHG emissions until 2050 will be very slight, mainly influenced by the ban on F-gases. According to the current projections (Tab. 2-291529 and Fig. 2-8), it is expected that total emissions from 2. IPPU in 2050 will decrease by 25% compared to year 1990 and by 21% compared to 2018. Emission projections are based on the current situation in the Czech industry and legislation. However, it is highly probable that during next few years, producers will renovate their units and introduce new mitigation techniques and thus there is a space for reduction of GHG emissions from 2. IPPU.

Tab. 2-2915 Reported and projected emissions of GHG in 2. IPPU – WEM scenario

[Mt CO_2 eq.]	Reported emissions			Projected emissions							Difference [%]			
	1990	**2005**	**2018**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**	**1990 – 2020**	**1990 – 2030**	**1990 – 2040**	**1990 – 2050**
WEM	17.11	14.83	16.26	16.16	14.67	13.86	13.18	12.85	12.88	12.77	-5.59	-19.01	-24.91	-25.35

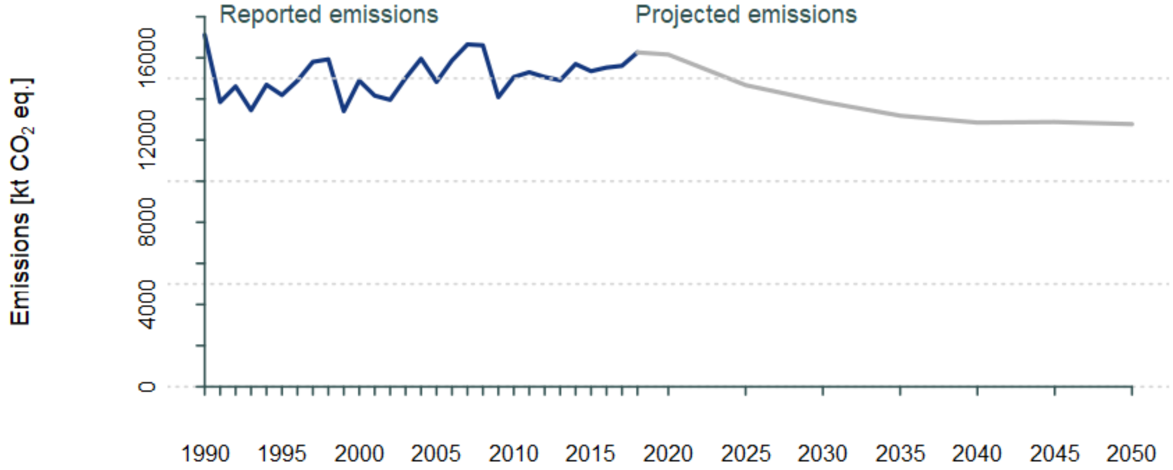


Fig. 2-8 Reported and projected emissions of GHG in IPPU – WEM scenario

Projected greenhouse gas emissions 'With existing measures (WEM) scenario'

WEM scenario takes into account following policies and measures:

Regulation No 517/2014,
Directive 2006/40/EC,
Kigali Amendment of the Montreal Protocol.

As visible from Tab. 2-160, major share on total emissions from 2. IPPU has by far CO_2. It is expected that emissions of CO_2 will be stagnant until 2050, as no major changes are expected in 2.A Mineral, 2.B Chemical or 2.C Metal industry and thus emissions will not change rapidly. Only a small decrease of CO_2 emissions compared to the current situation is expected. No significant changes are expected in CH_4 emissions, where the main source is sinter production. N_2O emissions are expected to raise with the anticipated increase of its main source, the N_2O production.

Tab. 2-160 Breakdown of reported and projected emissions of GHG by gases in 2. IPPU - WEM scenario

[Mt CO_2 eq.]	Reported emissions			Projected emissions							Difference [%]			
	1990	2005	2018	2020	2025	2030	2035	2040	2045	2050	1990 – 2020	1990 – 2030	1990 – 2040	1990 – 2050
CO_2	15.65	12.39	11.98	11.89	11.64	11.63	11.54	11.49	11.46	11.42	-23.99	-25.65	-26.55	-27.00
CH_4	0.05	0.06	0.06	0.07	0.07	0.07	0.07	0.07	0.07	0.07	29.97	31.60	31.53	31.54
N_2O	1.33	1.17	0.41	0.43	0.44	0.44	0.44	0.45	0.64	0.65	-68.06	-67.19	-66.24	-51.25
HFCs	NO	1.07	3.74	3.70	2.46	1.66	1.08	0.79	0.67	0.59	NA	NA	NA	NA
PFCs	NO	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	NA	NA	NA	NA
SF6	0.08	0.11	0.07	0.07	0.06	0.05	0.04	0.04	0.04	0.03	-20.33	-40.05	-53.01	-61.38
NF3	NO	NO	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	NA	NA	NA	NA
Total	17.11	14.83	16.26	16.16	14.67	13.86	13.18	12.85	12.88	12.77	-5.59	-19.01	-24.91	-25.35

Legislation currently in force is focusing on F-gas emissions reduction, mainly HFCs, which are used extensively in 2.F.1 Refrigeration and air conditioning systems. The applicable policies and measures (PaM) are reflected in the presented projections. Reported and projected emissions of F-gases are shown in Tab. 2-160 and overall results of F-gases projections in Fig. 2-9. Decrease of HFCs, PFCs, NF_3 emissions compared to 1990 cannot be calculated because at that time these F-gases were not used in the Czech Republic and thus emissions are reported as not occurring (NO) (Tab. 2-160). Therefore, the base year for F-gases is 1995 (CHMI, 2020) (IPCC, 2006). It is expected that HFCs emissions will start to decrease around 2020. Compared to 2018, HFCs emissions should be 83% lower in 2050. The decrease of F-gases emissions will not be as rapid as one could expect because released during the equipment's lifetime, which in some cases can be more than a decade. SF_6 and NF_3 are used by semiconductor manufacturers and SF_6 also as and insulation gas in switchgears. Emissions of SF_6 will start to decline unlike emissions of NF_3, which is expected to be more commonly used in near future. For NF_3 is expected that emissions will increase unless new PaM will be adopted. PFCs are not used anymore in the Czech Republic but formation of CF_4 as a byproduct during etching and cleaning in semiconductor industry is taken into account and thus emissions will be still occurring.

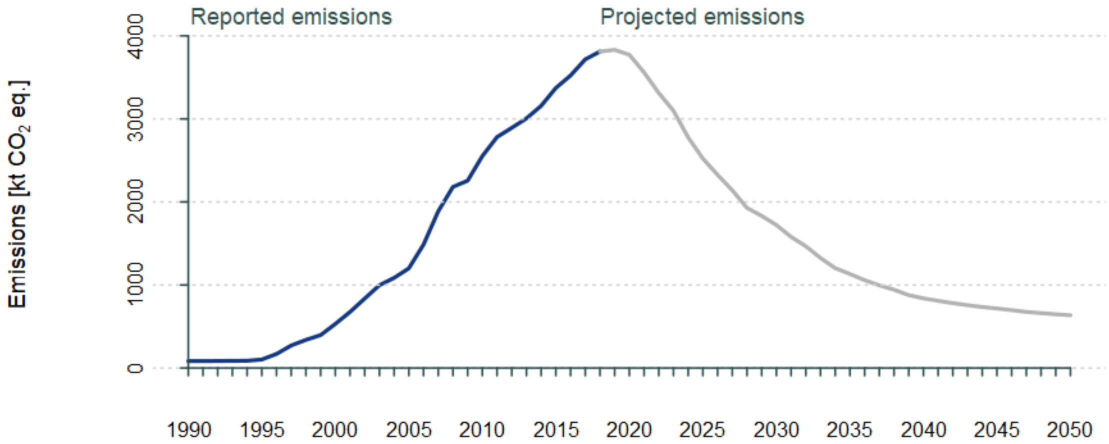


Fig. 2-9 Reported and projected F-gases (HFCs, PFCs, SF_6, NF_3) emissions from categories 2.E, 2.F, 2.G – WEM scenario

As shown in Tab. 2-171, GHG emissions decline is expected in comparison to 1990 for all categories, except 2.D Non-energy use of fuels. Emissions from 2.A Mineral industry are projected to decrease in 2020 and then slightly increase until 2050. This trend directly follows projections of cement production (MIT, 2020). It is expected that emissions from 2.B Chemical industry will slightly decrease until 2050. 2.C.1 Iron and steel production is the main emission subcategory of 2. IPPU. It is expected that the 2.C.1 production and thus emissions are going to slightly decrease compared to the current situation.

It is expected that F-gas emissions for category 2.E.1 Electronic industry will increase in the next few years because currently there is no legislative measure influencing F-gases use in this category. Projections for this category are based on positive correlation of F-gases consumption in semiconductor manufacturing with GDP but it should be taken into account that emissions from semiconductor manufacturing are under the threshold of significance (0.05%). The main source of F-gas emissions is category 2.F Product uses as substitutes for ODS, in particular subcategory 2.F.1 Refrigeration and air conditioning. It is expected that emissions will start decreasing when important deadlines banning certain substances (Regulation No 517/2014) enter into force.

Tab. 2-171 Breakdown of reported and projected emissions of GHG by individual categories in 2. IPPU - WEM scenario

[Mt CO_2 eq.]	Reported emissions			Projected emissions							Difference [%]			
	1990	2005	2018	2020	2025	2030	2035	2040	2045	2050	1990 – 2020	1990 – 2030	1990 – 2040	1990 – 2050
2.A. Mineral industry	4.08	3.35	3.08	2.88	2.89	2.90	2.91	2.93	2.97	3.00	-29.51	-29.01	-28.15	-26.49
2.B. Chemical industry	2.94	2.84	2.05	2.19	2.13	2.06	2.00	1.94	2.06	2.00	-25.58	-29.91	-34.21	-32.16

2.C. Metal industry	9.67	7.10	6.95	6.96	6.77	6.82	6.78	6.78	6.78	6.78	-28.03	-29.52	-29.90	-29.90
2.D. Non-energy products from fuels and solvent use	0.13	0.13	0.15	0.13	0.14	0.14	0.14	0.14	0.14	0.14	5.45	9.35	9.10	9.14
2.E. Electronics industry	NO	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	NA	NA	NA	NA
2.F. Product uses as substitutes for ODS	NO	1.08	3.74	3.70	2.46	1.66	1.08	0.79	0.67	0.59	NA	NA	NA	NA
2.G. Other product manufacture and use	0.29	0.32	0.29	0.29	0.28	0.27	0.26	0.26	0.25	0.25	-1.20	-7.51	-11.89	-14.91
2.H. Other	NO	NO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	NA	NA	NA	NA
Total	17.11	14.83	16.26	16.16	14.67	13.86	13.18	12.85	12.88	12.77	-5.59	-19.01	-24.91	-25.35

Projected greenhouse gas emissions 'With additional measures (WAM) scenario'

There is no additional measure for 2. IPPU sector and so WAM is the same as WEM.

2.3.1.3. Sensitivity analysis

Projections of GHG emissions from 2. IPPU sector are based on calculation sheets used for inventory emission estimates in NIR (CHMI, 2020). Activity data is only variable which changes during projected period 2019 – 2050 (see chapter 2.3 for detailed information about activity data projections). EFs are constant during projected period and thus sensitivity analysis would not bring any interesting outcomes for categories under 2. IPPU sector (except category 2.F.1). If activity data will change by ±5% then emissions will change by ±5%, because emission factors used for inventory emission estimates are constant during the projected period.

Only category where sensitivity analysis could bring interesting output is category 2.F.1 Refrigeration and air conditioning, which is also a key category (CHMI, 2020). The projections are prepared with national model Phoenix, which takes into account a specific approach for calculating the amount of chemicals remaining in the equipment at decommissioning, using the Gaussian distribution model with mean at the lifetime expectancy for newly filled equipment and assuming only half lifetime expectancy for serviced equipment (Ondrusova & Krtkova, 2018(1)). Sensitivity analysis for category 2.F.1 is implemented using variable consumption of F-gases by ±5%, while respecting the emission trend from NIR (CHMI, 2020). The result of the sensitivity analysis is depicted in Tab. 2-182 and Fig. 2-30.

Tab. 2-182 Sensitivity analysis using variable consumption of F-gases in category 2.F.1 under 2. IPPU sector

Emission difference [%]	2020	2025	2030	2035	2040	2045	2050
WEM and WEM +5%	1.36	3.21	4.08	7.99	4.58	5.07	5.13
WEM and WEM -5%	-1.36	-3.21	-4.08	-5.39	-5.06	-5.07	-5.13

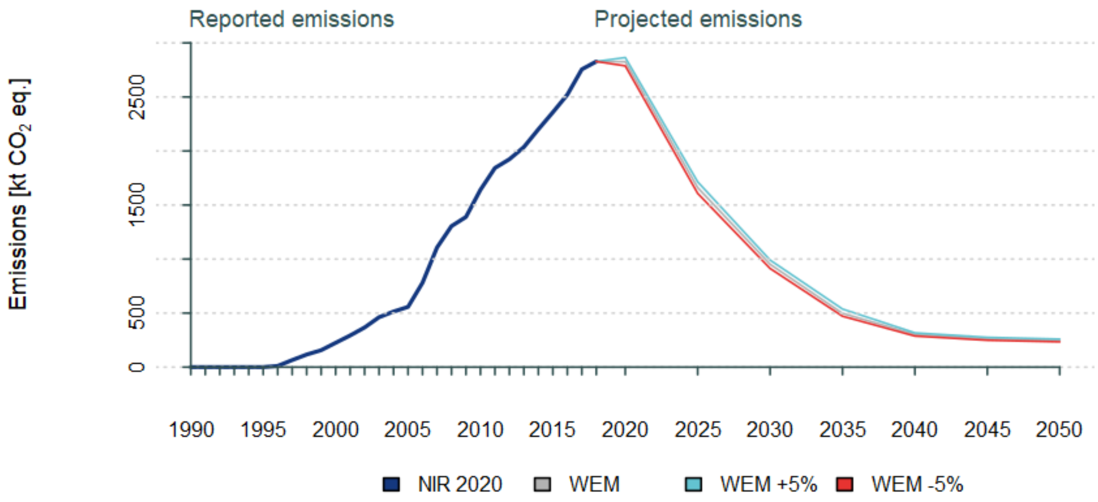


Fig. 2-30 Sensitivity analysis using variable consumption of F-gases in category 2.F.1 under 2. IPPU sector

2.3.1.4. Difference between previously and currently reported projections

Since current and previous projections are based on the same methodology, differences are mainly due to the changes in updated activity data. The most visible difference is for F-gases projections. The decrease of F-gases emissions were projected to be slower in previous projections (2019). The increase in the current projection is caused by changed approach to activity data projections, where the gases used for servicing were included in consumption next to the first fill, whose projections is decreasing according to adopted legislative measures.

2.4.Agriculture

In terms of greenhouse gas (GHG) emissions in the country, Agriculture is the third largest sector in the Czech Republic. In 2018, it produced 6.46% of total GHG emissions (incl. LULUCF and indirect emissions) which is 8,606 kt CO_2 eq., 49% originated from Agricultural Soils, 35% from Enteric Fermentation and 12% from Manure Management. Carbon dioxide (CO_2) emissions from Liming and Urea application on agricultural soils contribute with 3% of the total agricultural emissions in 2018. The share of emissions categories in the total emissions has changed since 2016 when the new animal waste management system (AWMS) including anaerobic digesters was incorporated into the estimate. While the share of emissions from Manure Management decreased since 1990, the share of emissions from Agricultural soils increased because of it.

The total emissions from Agriculture decreased by about 45% from the beginning of the reported period (1990). The quantitative overview and emission trends in the reported period are provided in Fig. 2-1, Tab. 2-3203 and 2-40 (CHMI, 2020).

Tab. 2-193 Emissions of Agriculture in period 1990-2018 (sorted by categories) (CHMI, 2020)

Year	TOTAL	Enteric Fermentation (3.A)	Manure Management (3.B)	Managed soils (3.D)	Liming (3.G)	Urea Application (3.H)
	Unit [kt CO_2 eq.]					
1990	15 649	5 601	3 125	5 627	1 188	109
1991	13 536	5 284	2 986	4 817	316	132
1992	11 684	4 740	2 790	3 936	109	109
1993	10 405	4 111	2 560	3 537	104	93
1994	9 430	3 603	2 249	3 383	104	91
1995	9 442	3 506	2 131	3 585	111	109
1996	9 146	3 472	2 096	3 363	113	100
1997	8 780	3 246	2 015	3 358	93	67
1998	8 430	3 041	1 949	3 206	91	143
1999	8 465	3 112	1 972	3 206	88	88
2000	8 554	2 989	1 899	3 505	113	48
2001	8 888	3 013	1 862	3 830	105	77
2002	8 560	2 950	1 875	3 571	100	64
2003	8 037	2 920	1 863	3 114	79	61
2004	8 464	2 856	1 770	3 691	77	70
2005	8 187	2 799	1 696	3 553	65	74
2006	8 131	2 757	1 670	3 542	78	83
2007	8 379	2 787	1 658	3 732	80	122
2008	8 446	2 819	1 587	3 844	96	100
2009	7 588	2 749	1 448	3 241	65	86
2010	7 484	2 657	1 402	3 252	62	111
2011	8 086	2 664	1 342	3 889	81	111
2012	8 019	2 696	1 329	3 766	117	136
2013	7 989	2 696	1 329	3 702	137	126
2014	8 049	2 752	1 306	3 783	152	57
2015	8 629	2 828	1 324	4 125	164	187
2016	8 859	2 888	1 015	4 578	168	211
2017	8 789	2 939	993	4 574	159	124
2018	8 606	3 039	1 050	4 229	161	126

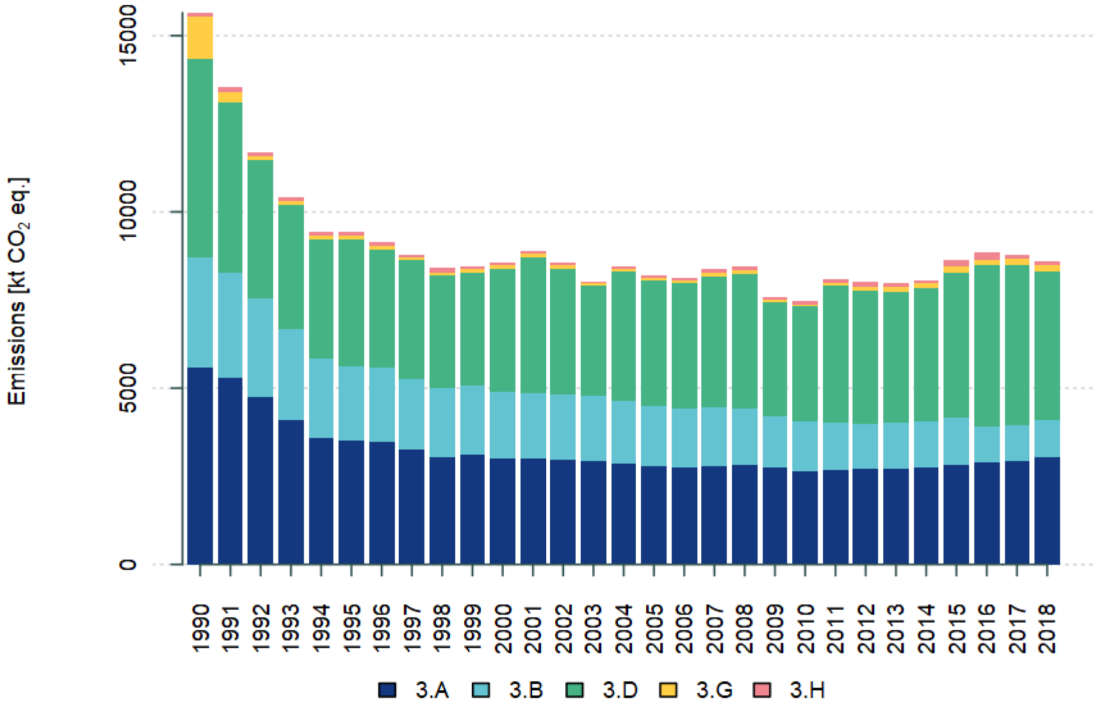


Fig. 2-11 The emission trend of agricultural sector in period 1990-2018 (CHMI, 2020)

The sum of emissions from Agriculture in the Czech Republic culminated in the beginning of the reporting period (in 1990) (Tab. 2-33, 2-34), the lowest emissions were estimated in 2010 (48% of the total emissions in 1990). The reason of the relatively significant decrease after 1990 was the decreasing population of livestock. The total emissions are relatively stable from 1997 till 2018 when they are fluctuating ±10% with the lowest level in 2010. While the Enteric Fermentation and Manure Management sources are relatively stable for more than 10 years, management of agricultural soils and application of limestone and dolomite have been increasing since 2006. In 2015 and 2016 the consumption of urea was the highest in the reporting period.

Tab. 2-320 Reported emissions in CO_2 eq. by emitted gases

GHG	Reported emissions						
[Mt CO_2 eq.]	1990	1995	2000	2005	2010	2015	2018
CO_2	1.30	0.22	0.16	0.14	0.17	0.35	0.29
CH_4	7.33	4.67	4.05	3.76	3.43	3.57	3.57
N_2O	7.02	4.51	4.34	4.28	3.88	4.71	4.75
Total	**15.65**	**9.44**	**8.55**	**8.18**	**7.48**	**8.63**	**8.61**

Source: CHMI 2020

2.4.1.1. Methodological issues

The projections presented in this report are based on the methodology used in the National Inventory Report (CHMI, 2020) in the Agriculture sector. Trends in activity data and the emission factors (EF) used in calculation were derived from the official documents (MoA, 2016) of the Ministry of Agriculture of the Czech Republic (further only Ministry of Agriculture) and from discussions with relevant experts of the Ministry of Agriculture (Section of Agriculture and Food Production, (MoA, 2020)) and from the cooperating experts of the Crop Research Institute (Klír & Wollnerová, 2020).

Ministry of Agriculture provided predicted development of following inputs for the period 2020-2050:

- livestock populations (number of heads per livestock categories),
- amount of nitrogen from fertilizers applied to agricultural soils,
- annual harvest production,
- annual milk production including milk quality data,
- amount of limestone and urea applied to agricultural soils.

An adapted Excel spreadsheet was used for predictions based on these provided data. Projected emissions are estimated by the Tier 2 and Tier 1 methodology described in the National Inventory Report (CHMI 2020). Additionally, the country specific data derived from the Czech legislation (Decree No.377/2013 Coll., On the storage and use of fertilizers) were used for the first time in this prediction. As of 2020, the use of country specific data instead of standard (default) data is being investigated by a group of experts in the frame of a research project funded by the Technological Agency of the Czech Republic (TACR Théta TK02010056TK). The implementation of these new sources to the inventory is planned for the submissions in 2021-2023.

For some activity data it was very difficult to forecast the future development (e.g., the amount of sewage sludge applied to soils etc.), and in such cases the constant values were therefore used in estimation.

The projected emissions in Agriculture retain the trend in the emissions reported for the 1990 - 2018 period (CHMI, 2020) considering the status and hypothetical developments in this sector. The trend series are consistent for both methane (CH_4) and nitrous oxide (N_2O). For CH_4, the decrease in emissions for enteric fermentation and manure management since 1990 relates to the decrease in the number of livestock (especially cattle and swine). Since 1994, it seems that agrarian conditions have settled down to the current level. The reduction of livestock population after 1990 is partly counterbalanced by an increase in cattle efficiency (increasing gross energy intake and milk production, body weight etc.) and by slight increase of populations.

Methane emissions

Enteric fermentation and manure management are the main sources of CH_4emissions in agriculture. Activity data, specifically livestock population data, such as number of cattle, swine, and poultry, are decisive for projections. Emissions from Enteric Fermentation are calculated by using Tier 2 (for cattle) and Tier 1 (for other livestock) methodologies presented in the IPCC 2006 GL. Methane (CH_4) emissions from Manure Management are calculated by using Tier 2 (for cattle and swine) and by Tier 1 (for other livestock).

Cattle EF for enteric fermentation is based on several input data connected to gross energy intake (milk production, milk quality, body weight etc.). The dependence of the EF for enteric fermentation on milk production and body weight development is summarized in Tab. 2-35, showing the reported and projected values.

Tab. 2-3521 Values of calculated emission factor (EF) for enteric fermentation for dairy cattle, relevant milk production and body weight, development within time period 1990-2050

Dairy cattle	Reported data	Projected data

	1990	2015	2018	2020	2025	2030	2035	2040	2045	2050
EF for enteric fermentation (kg CH_4/head/year)	97	141	153	156	156	162	162	167	167	171
Milk production (kg/day)	11	18	23	25	25	27	27	28	28	29
Body weight (kg)	520	590	650	670	670	670	670	670	670	670

The prediction of livestock population for projected period is shown in Tab. 2-362236. The sector development strategy published by the Ministry of Agriculture (MoA, 2016) (MoA, 2018) and validated by expert judgement (MoA, 2020) was used for this prediction. The cattle population rapidly declined during 1990 - 2011 (more than 60%). From 2012 the cattle population is slowly growing (about 0.5 - 2% per year) and similar trend is predicted for the period 2025 - 2050. The more intensive growth is predicted for swine population, specifically a rise to 40% within 2018 - 2050, and for poultry population with growth up to 10% from 2018 to 2050.

Tab. 2-3622 Activity data – livestock population within reported and projected period

	Reported data			Projected data						
Livestock population (in 1000s)	**1990**	**2015**	**2018**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Cattle	3 506	1 407	1 416	1 404	1 420	1 450	1 470	1 500	1 520	1 550
Swine	4 790	1 560	1557	1 499	1 600	1 700	2 000	2 200	2 200	2 200
Sheep	430	232	219	204	210	215	215	220	220	220
Goats	41	27	30	29	30	32	32	35	35	35
Horses	27	33	35	38	40	40	42	45	45	50
Poultry	31 981	22 508	23 573	24 247	24 200	25 000	25 500	26 000	26 500	27 000

Source: 1990, 2015 and 2018 (CZSO), 2020 -2050 (MoA, 2020)

The default EFs used to estimate CH_4 emissions according to Tier 1 procedures are taken from the National Inventory Report (CHMI, 2020) and IPCC Gl. (IPCC, 2006). Predicted values of EFs calculated according Tier 2 (Enteric Fermentation, cattle) are stated in the same spreadsheet as for the inventory estimation in which the forecasted input data were included (MoA, 2020). Emission factors for prediction of CH_4 emission from manure management are derived from Decree No. 377/2013 Coll., on the storage and use of fertilisers, for category cattle and swine. Default emissions factors (IPCC, 2006) are used for estimation in other livestock categories.

Nitrous oxide emissions

Manure management and agricultural soils are the main sources of N_2O emissions in the Agriculture sector. Direct and indirect emissions from manure management depend on livestock population and AWMS that is currently applied. Tier 2 (cattle) and Tier 1 (other livestock categories) are used for the associated GHG estimation in the National Inventory Report (CHMI, 2020).

Livestock population data, mainly numbers of cattle, swine, and poultry, are decisive for the projection (see previous chapter). The total N_2O emissions from Manure Management rapidly decreased by 50% during the period 1990 -2015 (CHMI, 2020). Another decrease by about 15 % occurred in this category within the period 2016-2018 when a new category of the manure management system was reflected in the inventory (anaerobic digestion).

Similarly, a decrease of emissions form Manure Management by about 25% is expected for the predicted period (2020-2025). Use of country specific data of nitrogen excretion rate (Nex) for all livestock categories is the reason of this decrease. The comparison of current values (CHMI, 2020) and country specific Nex rate data based on the Decree 377/2013 Coll., on the storage and use of fertilisers, is presented in Tab. 2-37.

Tab. 2-3723 Activity data – Nitrogen excretion rate, comparison of values currently in use for inventory and used in projection

	Nitrogen excretion rate kg N/head/year	
	Reported data (2018)	Projected data (2019 - 2050)
Dairy cattle	141.2	109.2
Other cattle	70.0	59.2
Swine	15.6	11.5
Sheep	15.5	9.0
Goats	23.4	9.0
Horses	58.5	49.8
Poultry	0.49	0.46

The total emissions from Agricultural Soils decreased by 25% since 1990 with a minimum in 2003. The amount of applied mineral nitrogen fertilizers is substantial for this category and its increasing consumption has a strong negative impact to environment. The future increase is not forecasted by the Ministry of Agriculture (Budnakova, 2018). The constant amount of nitrogen applied to the soil is therefore projected for the period 2020 – 2050, Tab. 2-38.

A prognosis of the total agricultural plant production is very uncertain. Crop harvest (Tab. 2-39) depends on climatic factors and trading preferences. The projections are based on strategical forecast of the Ministry of Agriculture (MoA, 2016) on development of sowing areas for agricultural crops and on some observed trends in demands of the Czech food consumer as well. According to the strategical expectations of the Ministry, the total crop area used for cereals production decreases to 1 300 000 ha in 2025 and the grassland category relevantly increases. The total area of agricultural land stays almost the same. The total arable land is slowly decreasing to the benefit of grassland area. Harvest prediction is based on statistical analysis of yields trends.

The following tables give the reported and forecasted activity data. The emission coefficients used for estimation of the N_2O emissions were taken from the National Inventory Report (CHMI, 2020). The methodology of emission estimation corresponds to the IPCC 2006 Gl (IPCC, 2006) and the emission categories are based on the common reporting format (CRF).

Tab. 2-3824 Activity data – application of mineral fertilizers reported and projected period

Mineral fertilizers [kt N]	Reported data			Projected data						
	1990	2015	2018	2020	2025	2030	2035	2040	2045	2050
	418	397	352	350	350	350	350	350	350	350

Source: CZSO, MoA 2020

Tab. 2-39 Activity data – annual harvests reported and projected period

Annual Harvest [kt]	Reported data			Projected data						
	1990	2015	2018	2020	2025	2030	2035	2040	2045	2050
Crops (cereals)	8 947	5 831	6 971	6 978	6 865	6 978	7 053	7 051	7 000	7 000
Pulses	152	95	80	70	80	93	93	94	90	90
Potatoes	1 755	505	584	622	662	722	724	726	700	700
Sugar beet	4 026	3 421	3 724	3 728	3 760	3 804	3 843	3 866	3 866	3 866
Fodder	7 444	2708	3 372	3 003	2 997	3 012	3 047	3 083	3 080	3 080
Soya	2	20	25	25	29	33	38	42	40	40

Source: CZSO, MoA 2020

Carbon dioxide emissions

There are two main sources of CO_2 emissions in Agriculture reported in the National Inventory Report (CHMI, 2020):

1. Liming (3.G)
2. Urea Application (3.H)

Liming is used to reduce soil acidity and improve plant growth in managed systems, particularly agricultural lands, and managed forests. Adding carbonates to soils in the form of lime (e.g., limestone or dolomite) leads to CO_2 emissions as the carbonate lime dissolves and releases bicarbonate. Adding urea to soils during fertilization leads to a loss of CO_2 that was fixed in the industrial production process.

Prediction of activity data developments is presented in Tab. 2-39. Increase by about 13% is predicted for consumption of limestone included dolomite and increase by about 60 % is predicted for consumption of urea, predicted period for both is 2020-2050. The predicted values represent an upper estimate.

Tier 1 methods are used for estimation of CO_2 emissions from both sources (CHMI, 2020). The following table gives the reported and forecasted activity data.

Tab. 2-250 Activity data – application of limestone and urea within reported and projected period

Applied [kt]	Reported data (NIR 2021)			Projected data						
	1990	2015	2018	2020	2025	2030	2035	2040	2045	2050
Lime	2 676	371	354	400	450	450	450	450	450	450
Urea	148	365*	253*	400	400	400	400	400	400	400

Source: CZSO, (MoA, 2020)

**Due a technical error the different values (amount of urea applied as fertilizers) were used in the NIR 2020 (CHMI, 2020).*

2.4.1.2. Projected greenhouse gas emissions ‘With existing measures (WEM) scenario’ and ‘With additional measures (WAM) scenario’

The WEM scenarios include corresponding policies and measures as described in chapter 1.4. Most policies and measures, including objectives of conceptual strategy, originate from the Strategy of Ministry of Agriculture (MoA, 2016, MoA, 2020), mentioned in the Chapter “Indicative Indicators of Strategical Objectives”.

There are no additional measures planned to decrease GHG emissions in the Agriculture sector currently. Therefore, there are no differences between WEM and WAM scenario.

A relatively moderate increasing trend in the production of GHGs in Agriculture is expected, according to WEM scenario. The total emissions in 2050 should be approximately 2% above the total estimated in 2018 (base year).

The current economic and financial situation entails considerable uncertainties in predicting the long-term emission trends in the Agriculture sector. Due to relatively small contribution of Agriculture (7%) to total GHG emissions in the Czech Republic, the impact of emission changes is not significant for the total emission trend. The noted emission changes are caused by changes in activity data – increase of livestock populations and consumption of urea. Specifically, the predicted growth of animal production has a strong effect on the GHG emissions in the Agriculture sector. This effect will be partly reduced by planned transition to country specific data input to estimation. Specifically, these are Nex rates for all livestock categories and CH_4 EF for cattle and swine for submission 2022.

Tab. 2-261 Reported and projected emissions of GHG in Agriculture – WEM scenario

[Mt CO_2 eq.]	Reported emissions			Projected emissions						
	1990	2015	2018	2020	2025	2030	2035	2040	2045	2050
WEM	15.65	8.63	8.61	8.14	8.17	8.37	8.49	8.67	8.71	8.82

	Difference [%]			
	1990–2020	1990 – 2030	1990 – 2040	1990 – 2050
WEM	- 47.9	- 46.5	- 44.6	- 43.6

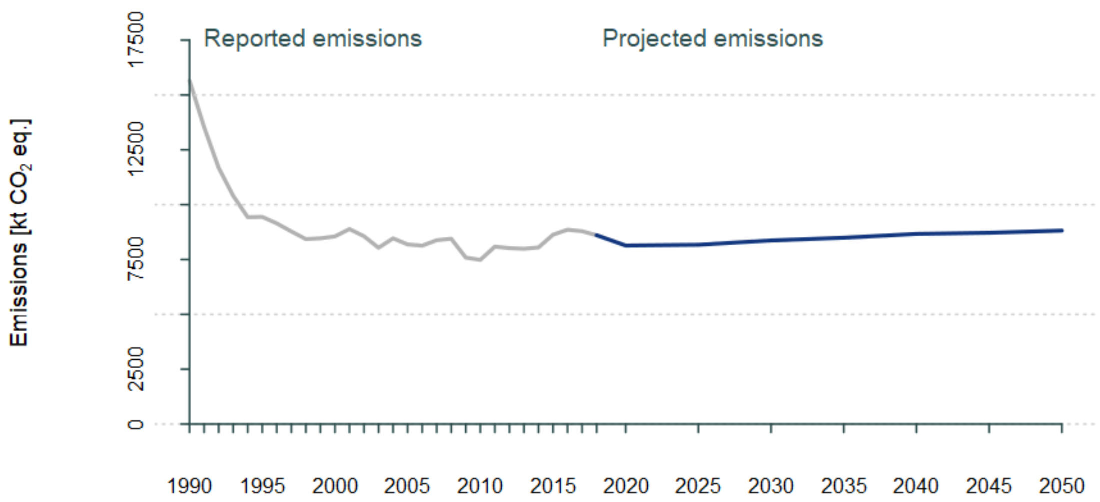


Fig. 2-12 Reported and projected emissions of GHG in Agriculture – WEM scenario

Projected greenhouse gas emissions 'With existing measures (WEM) scenario'

The WEM scenario considers the policies and measures adopted and implemented until June 2020. The breakdown of reported and projected (WEM scenario) emissions by gases and individual categories is shown in Tab. 2-271, Tab. 2-42, Tab 2-43.

The projections are based on the trends of the key activity data including livestock population, milk production and amount of nitrogen applied to agricultural soils and crop harvest.

The estimate of the number of animals for the projected period is based on strategy published by Ministry of Agriculture in 2016 (MoA, 2016) updated in 2020 (MoA, 2020) according the recent development in the Agriculture sector. The new forecast lowers the originally estimated increase of livestock population than the previous one.

Methane emissions (CH_4) coming from enteric fermentation and manure management is projected to grow from 3.57 Mt CO_2 eq. in 2018 to 3.97 Mt CO_2 eq. in 2050 due to the predicted increase of livestock population. The predicted growth is estimated by about 11% in comparison with the base year (2018).

Nitrous oxide (N_2O) emissions include emissions from manure management and from agricultural soils. The projected trend is slightly decreasing from 4.75 Mt CO_2 eq. in the base year (2018) to 4.38 Mt CO_2 eq. in 2050. The predicted reduction is estimated by about 8% in comparison with the base year (2018). Reduction is a result of expected transition to country specific data for $CH_4$and N_20 emissions from manure management.

Prediction of CO_2 emissions assumes that the consumption of urea and DAM fertilizers increases in comparison with the base year (2018). The projected trend is increasing from 0.29 Mt CO_2 eq. in the base year (2018) to 0.47 Mt CO_2 eq. in 2050. The predicted increase is estimated by about 62% in comparison with the base year (2018).

The total of 2% GHG emissions increase is expected by the end of the projected period (2050) in comparison with the base year (2018).

Tab. 2-272 Breakdown of reported and projected emissions of GHG by gases in agriculture - WEM scenario

GHG	Reported emissions			Projected emissions						
[Mt CO_2 eq.]	1990	2015	2018	2020	2025	2030	2035	2040	2045	2050
CO_2	1.30	0.35	0.29	0.47	0.47	0.47	0.47	0.47	0.47	0.47
CH_4	7.33	3.57	3.57	3.44	3.46	3.62	3.70	3.83	3.87	3.97
N_2O	7.02	4.71	4.75	4.23	4.24	4.28	4.32	4.36	4.37	4.38
Total	**15.65**	**8.63**	**8.61**	**8.14**	**8.17**	**8.37**	**8.49**	**8.67**	**8.72**	**8.82**

GHG	Difference [%]			
	1990 – 2020	1990 – 2030	1990 – 2040	1990-2050
CO_2	- 63.84	- 63.84	- 63.84	- 63.84
CH_4	- 53.07	- 50.61	- 47.75	- 45.84
N_2O	- 39.74	- 39.03	- 37.89	- 37.61
Total	**- 47.99**	**- 46.52**	**- 44.60**	**- 43. 64**

The trend in the emission growth is not balanced in all source categories. The following trend is expected in the projected period 2020-2050. Emissions from Manure Management will decline by about 12% and those from Enteric Fermentation will grow by about 16%, N_2O emissions from the Agricultural Soils will decrease by about 8%. The emissions from Liming and Urea application will increase by about 13 % and 123%, respectively.

Tab. 2-283 Breakdown of the reported and projected emissions of GHG by categories in agriculture - WEM scenario

GHG source category	Reported emissions	Projected emissions

[Mt CO_2 eq.]	1990	2015	2018	2020	2025	2030	2035	2040	2045	2050
3.A Enteric fermentation	5.60	2.83	3.04	3.10	3.11	3.25	3.30	3.41	3.45	3.54
3.B Manure management	3.12	1.32	1.05	0.77	0.79	0.81	0.86	0.90	0.90	0.92
3.D Agricultural soils	5.63	4.13	4.23	3.80	3.81	3.83	3.86	3.89	3.89	3.89
3.G Liming	1.19	0.16	0.16	0.18	0.18	0.18	0.18	0.18	0.18	0.18
3.H Urea application	0.11	0.19	0.13	0.29	0.29	0.29	0.29	0.29	0.29	0.29
Total	**15.65**	**8.46**	**8.61**	**8.14**	**8.17**	**8.37**	**8.49**	**8.67**	**8.72**	**8.82**

GHG source category	Difference [%]			
	1990 – 2020	1990 – 2030	1990 – 2040	1990-2050
3.A Enteric fermentation	- 44.64	- 41.96	- 39.11	- 36.79
3.B Manure management	- 75.32	- 74.04	- 71.15	- 70.51
3.D Agricultural soils	- 32.50	- 31.97	- 30.91	- 30.91
3.G Liming	- 84.87	- 84.87	- 84.87	- 84.87
3.H Urea application	+ 62.07	+ 62.07	+ 62.07	+ 62.07
Total	**- 47.99**	**- 46.52**	**- 44.60**	**- 43. 64**

Projected greenhouse gas emissions 'With additional measures (WAM) scenario'

There are no additional measures planned to decrease GHG emissions in the Agriculture sector currently. Therefore, there are no differences between WEM and WAM scenario.

2.4.1.3. Sensitivity analysis

The projections of GHG emissions from Agriculture are based on the calculation sheets used for emission estimates in the National Inventory Report (CHMI, 2020). It uses activity data projected for the period 2020–2050 (see chapter 2.3 for more detailed information about projections of activity data). Most of the emission factors remain constant during the projected period and thus sensitivity analysis would not bring any interesting outcomes. If activity data change by ±5% then also the estimated emissions would change by ±5%. There is one exception – cattle EF for enteric fermentation, which depends on cattle productivity.

The sensitivity of the estimate is shown in Tab. 2-44. Emission factor is slightly growing correspondingly to growing milk production. The difference slightly growing by about 4% (2030) to 10% (2050).

The effect to total emissions from dairy cattle is below 1% of the total emissions from Agriculture.

Tab. 2-44 The comparison of projected and reported value of CH_4 emission factor (EF) for enteric fermentation, sensitivity of calculation

Dairy cattle	Projected data						
	2020	2025	2030	2035	2040	2045	2050
EF for enteric fermentation (kg CH_4/head/year) Calculated with projected milk production	156	156	162	162	167	167	171
EF for enteric fermentation (kg CH_4/head/year) Calculated with constant milk production (2018)	155	155	155	155	155	155	155

2.4.1.4. Difference between previously and currently reported projections

The current projection estimates are lower than those of the earlier projections. The forecasted smaller livestock population growth produces a lower level of GHG emissions in the projected period Tab. 2-429. The increase of emissions between year 2005 and 2030 was 19% for earlier projections (2019) and 16% for the current projections.

Tab. 2-429 The comparison of projected value of GHG emissions in projections estimated in 2017, 2019 (CHMI 2017, CHMI 2019) and the current projection (2021)

[Mt CO_2 eq.]	2015	2016	2017	2018	2020	2025	2030	2035	2040	2045	2050
WEM 2017	8.36				8.64	9.12	9.68	9.90			
WAM 2017	8.36				8.47	8.85	9.30	9.40			
WEM 2019	8.16	8.55	8.64		8.36	8.77	9.05	9.15	9.17		
WEM 2021	8.63	8.86	8.79	8.61	8.14	8.17	8.37	8.49	8.67	8.72	8.82

2.5.Land Use, Land-Use Change and Forestry

4. Land use, land-use change and forestry (LULUCF) is a specific sector within the emission inventory framework, as it is the only one able to directly offset CO_2 emissions due to photosynthetic fixation of carbon in plants and increasing individual ecosystem carbon pools. Carbon accounting has always been challenging for the 4. LULUCF sector, despite voluminous methodological advice compiled specifically for this sector by the International Panel on Climate Change (IPCC) (IPCC, 2003) (IPCC, 2006) (IPCC, 2014a) (IPCC, 2014b) (IPCC, 2019). Therefore, the estimates related to the 4. LULUCF sector are commonly accompanied by the largest uncertainty, often in range of tens of percent and larger.

The estimated and reported emissions by the individual 4. LULUCF sub-categories for the period 1990 to 2018 are shown in Fig. 2-43 below. The emissions are expressed in units of CO_2 eq., including CO_2, CH_4 and N_2O. The dominant greenhouse gas (GHG) in the 4. LULUCF sector is CO_2, whereas the contribution of other two gases is fragmental - two orders of magnitude smaller. Therefore, the individual gases are not specifically discerned in Fig. 2-43, but can be found in the latest National Inventory Report (NIR) (CHMI, 2020).

As apparent from Fig. 2-43, the emission quantities are largely determined by carbon stock changes in 4.A Forest land, followed by contribution of 4.G Harvested wood products (HWP), whereas the contribution of other categories is minor.

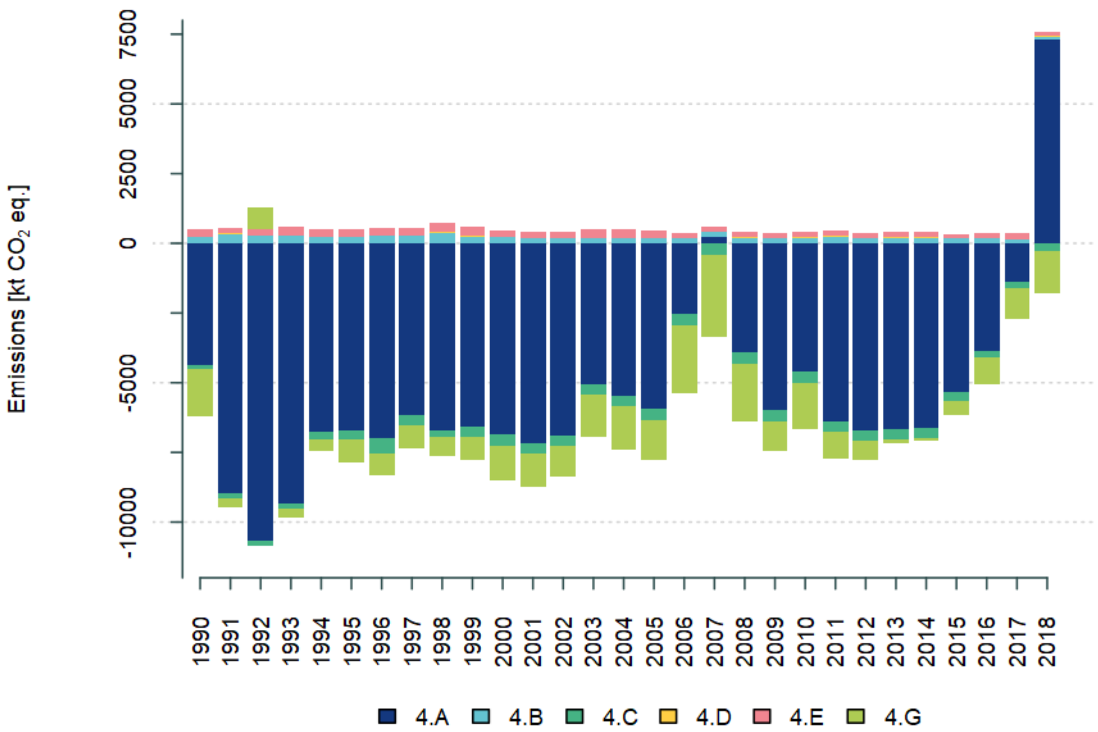


Fig. 2-43 The emission trend in 4. LULUCF sector during reporting period 1990 - 2018 (CHMI, 2020)

2.5.1.1. Methodological issues

There are several fundamental methodological steps of emission estimates in the 4. LULUCF sector, which must accordingly be considered in designing projections. These include a) treatment of land use areas b) emission estimates for individual land-use categories c) including 4.G HWP contribution. These steps are described below and summarized in Tab. 2-49.

a) Treatment of land use areas

The emission estimates in the 4. LULUCF sector are to a large degree determined by development of land areas categorized by their use. Therefore, the 4. LULUCF emission estimates and their projections must primarily methodologically solve the issue of land areas. The data on areas used in National Inventory Reporting (CHMI, 2020) are exclusively based on the cadastral land use information of the Czech Office for Surveying, Mapping and Cadastre (COSMC; www.cuzk.cz). The land-use representation and the land-use change identification system of the 4. LULUCF emission inventory use annually updated COSMC data, elaborated at the level of about 13 000 individual cadastral units. The observed development of the major IPCC land use categories (IPCC, 2006) is reported in NIR (CHMI, 2020).

The projections beyond 2018 are based on the observed trends, additional data from 2019 (known when preparing this material) and anticipation of in general gradually diminishing category-specific land use changes until 2050. Specifically, for land use categories 4.A Forest land and 4.C Grassland, a half-declining trend with respect to the changes since 1990 is foreseen for the period until 2050. For 4.D Wetlands and 4.E Settlements, a continuation of the trend since 1990 is foreseen. The trend projections of land areas are constructed based on either nonlinear fit using a sigmoid function (4.A Forest land, 4.E Settlement), parabolic function (4.C Grassland), or linear fit (4.D Wetlands). For 4.B Cropland, the estimate is given by balancing total land area with the other projected land use categories.

The historical and projected land use areas are shown in Tab. 2-6 and Fig. 2-54 below. There is an increase of land use categories 4.A Forest land, 4.C Grassland, 4.D Wetlands and 4.E Settlements. The area of 4.B Cropland is expected to further decrease. The changes in the land use category 4.B (Cropland) is, in both relative and absolute numbers, the most significant shift in land use expected in the country for the period 2018 - 2050, the end year of the projection period. During that time, the area share of 4.B Cropland would decrease from 40.5% to 38.6% in the country (Fig. 2-65), which means a loss of 152 kha in this period.

Tab. 2-46 Land use areas (kha): reported until 2018, projected until 2050 (*IE - areas of 4.F Other land are included within 4.E Settlements)

	Reported area [kha]						Projected area [kha]						
Land use category	**1990**	**2000**	**2005**	**2010**	**2015**	**2018**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
4.A Forest land	2629	2637	2647	2657	2668	2673	2678	2685	2689	2692	2695	2695	2695
4.B Cropland	3455	3319	3286	3248	3211	3193	3156	3123	3098	3079	3064	3051	3041
4.C Grassland	833	961	974	986	1015	1026	1033	1048	1061	1073	1083	1092	1100
4.D Wetlands	158	159	161	163	165	167	166	168	169	171	173	174	176
4.E Settlements	812	810	819	833	841	849	854	864	870	873	874	875	875
4.F Other land*	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE

Source: CHMI 2020, IFER (unpublished data)

Fig. 2-54 Actual areas of the major IPCC land use categories in the Czech Republic for the period 1990 to 2018 and the projected trends shown for the period until 2050. Within each category, a note on extrapolation approach is provided.

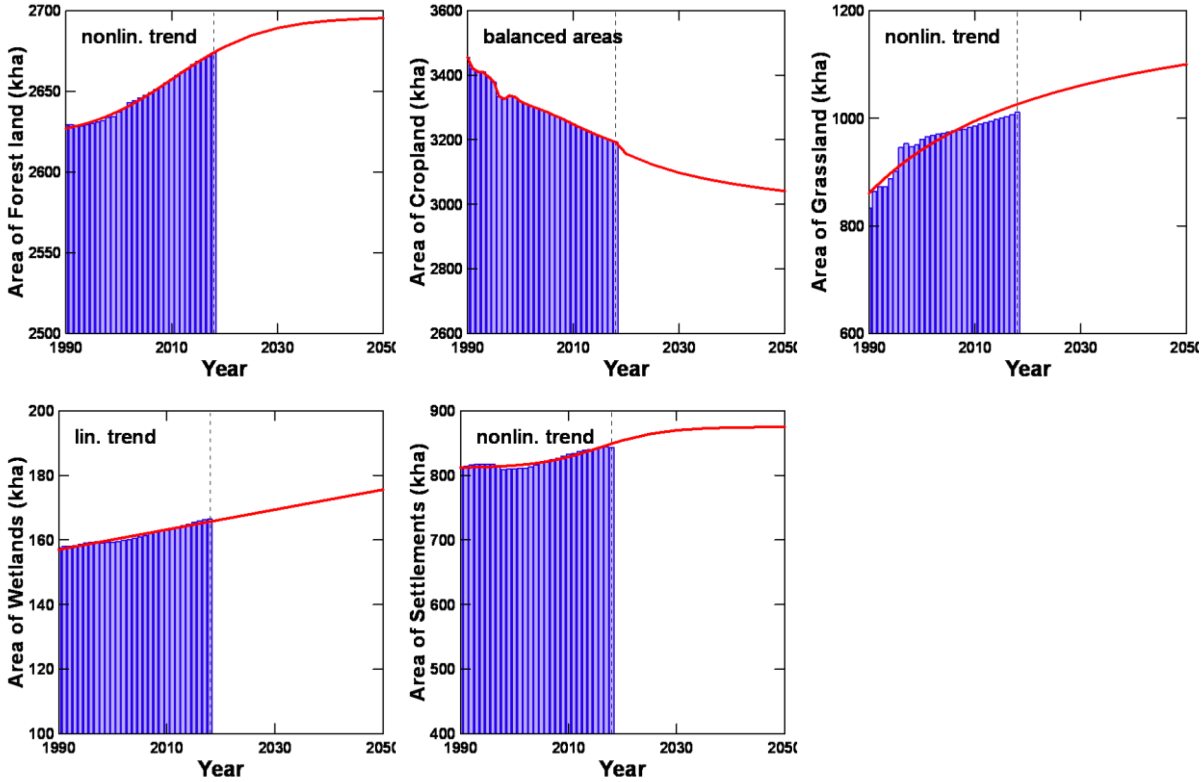
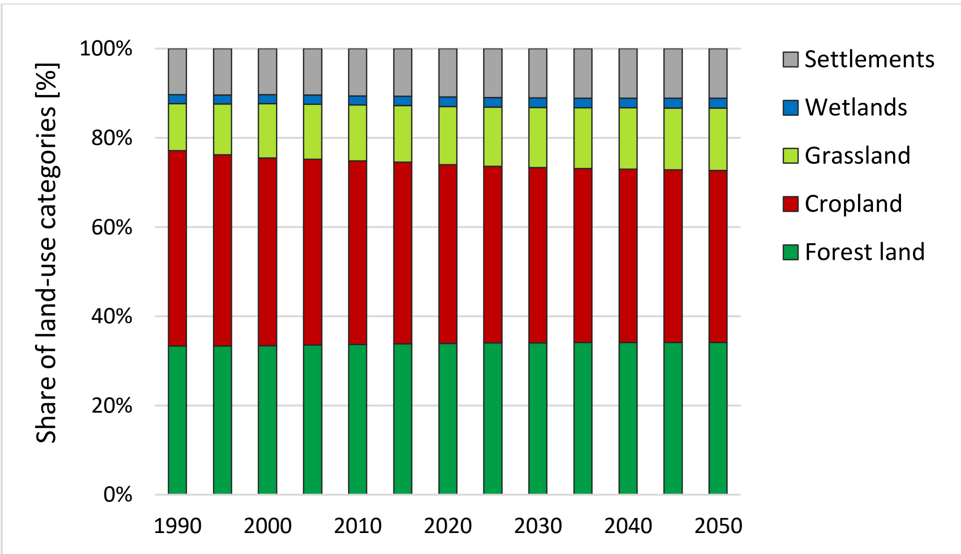


*Fig. 2-65 Share of areas for the six IPCC land use categories (*4.E Settlements also include a fraction representing an area of 4.F Other land) in 5-year intervals since 1990 to 2050, using the actual data (until year 2015 in the graph) and projections until 2050.*



b) Emission estimates for individual land-use categories

Secondarily, following the projection setup of land use areas, the projections of emission estimates for individual categories are prepared.

Specific attention is given to 4.A Forest land, which always represents the key emission category of the 4. LULUCF sector as well as within the entire NIR (CHMI 2020). For this reason, the projections related to forestry are elaborated using the dedicated internationally referenced forest modelling tool. While the earlier projections of forest resources used EFISCEN – the European Forest Information Scenario Model (Sallnas, 1990) (Pussinen et al, 2001) (Schelhaas et al., 2004) (Cienciala, et al., 2008) (Verkerk at al., 2017) this material adopts another tool. Namely the Operational Scale Carbon Budget Model of the Canadian Forest Service (CBM-CFS3, v. 1.2) (Kull, et al., 2016) was chosen for this study for its coherence with the GHG emission reporting of 4. LULUCF sector under UNFCCC and dedicated IPCC methodologies (Kurz et al., 2009; Federici et al., 2014). CBM-CFS3 is an empirical model driven by yield and standing inventory data, the same as used by operational foresters in timber supply analysis and forest management planning tools. In contrast to EFISCEN, CBM-CFS3 works with a daily time step and permits much more detailed budgeting of carbon pools. On the other hand, its application is more demanding in terms of both input information and expert knowledge.

Both models have previously been used to project forest resources of the Czech Republic. EFISCEN was used earlier to analyze forest development under various management scenarios (Schelhaas et al., 2004) (Cienciala, et al., 2008) (Nabuurs et al., 2018). In the context of UNFCCC GHG emission inventories, EFISCEN was used under Kyoto Protocol to construct Forest Management Reference Levels (FMRL) for over 15 European countries (including the Czech Republic) in coordination with the Joint Research Centre (JRC), Ispra, Italy. As for CBM-CFS3, this model was recently selected as the main tool for setting up the national Forest Reference Level (FRL) under EU Regulation 2018/841 for the period 2021-2025, which is described in detail in the Czech National Forest Accounting Plan (NFAP)[3]. Within the EU countries, CBM-CFS3 was also used for setting up FRL by Ireland and Poland (Korosuo, et al., 2020).

CBM-CFS3 model set-up for the Czech Republic

To use CBM-CFS3 in the Czech national circumstances, the European Archive Database as prepared by the JRC (Pilli et al., 2018) was modified to include the locally applicable biomass allometry functions for beech, pine, spruce and oak (Cienciala et al., 2006; 2008; Vonderach et al., 2018). Czech Republic comprises 5 climatic regions according to Hijmans et al. (Hijmans, et al., 2005). Since CBM-CFS3 does not consider precipitation in decay rates, only one climatic unit with a mean annual temperature of 7,5°C was employed. Finally, a background stem mortality of standing trees of 0.073 was used as assessed by the latest National Forest Inventory (Kučera & Adolt, 2020).

For this study, we used CBM-CFS3 using the Czech Republic with its forestry as the simulated domain, spatially categorized by NUTS3 regions (Fig. 2-76; regional labels as follows: CZ010 Prague, CZ020 Central Bohemia, CZ031 South Bohemia, CZ032 Plzeň, CZ041 Karlovy Vary, CZ042 Ústí nad Labem, CZ051 Liberec, CZ052 Hradec Králové, CZ053 Pardubice, CZ063 Vysočina, CZ064 South Moravia, CZ071 Olomouc, CZ072 Zlín, CZ080 Moravia-Silesia). The input data requested for the model run include growth and yield functions, current annual increment, growing stock data (m^3 under bark) aggregated by the main species groups and age classes, together with their associated specific areas. These data were provided by the Forest Management Institute (FMI), the administrator of the national database of forest management plans.

Apart from the above-described spatial categorization, forest data were categorized by species groups (Tab. 2-7). These included seven categories by the key tree species and or species of ecological importance. Additionally, temporarily unstocked areas and areas with dead standing spruce trees were treated individually.

The projection by CBM-CFS3 cover the period from 2019 to 2050. The carbon pools included in the projected emissions include living biomass and dead organic matter, which covers standing and lying deadwood of merchantable dimensions. This is identical as used in the NIR (CHMI, 2020).

[3] https://www.mzp.cz/C1257458002F0DC7/cz/opatreni_v_ramci_lulucf/$FILE/OEOK-CZ_NFAP_FRL_final-20200203.pdf

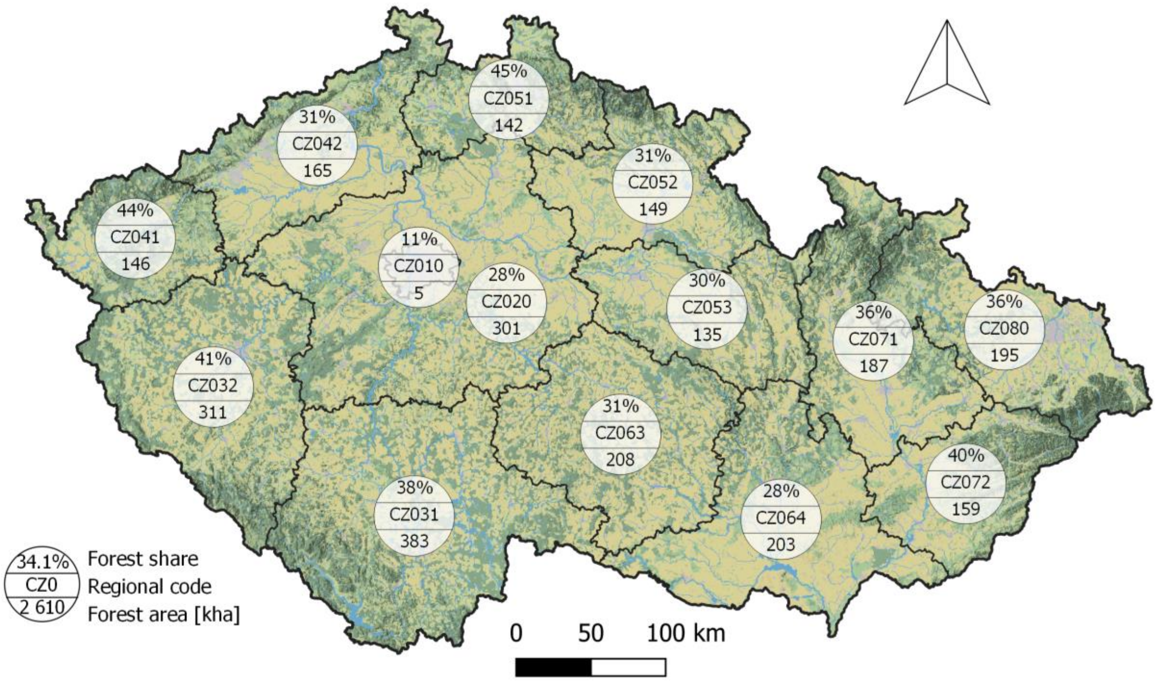


Fig. 2-76: Simulated domain 4.A Forest land area share and total 4.A Forest land area divided by the regions of Czech Republic (NUTS 3), showing the specific forestation (%) and forest area (kha) in 2018. The NUTS 3 legend shows overall total for the Czech Republic (MoA, 2020). Background map: Natural Czechia.

Tab. 2-47: Forest types by main tree species and corresponding area share by area and/or volume in 2018. Two additional categories are clearcut areas and spruce snag representing unprocessed dead standing spruce trees (assembled from data available on Forest Management Institute web depository – www.uhul.cz).

Forest type	Main species	Area share	Volume share
Spruce	*Picea abies (L.) Karst.*	49.6%	59.8%
Pine	*Pinus sylvestris L., Pinus nigra Arnold*	20.2%	19.9%
Beech	*Fagus sylvatica L.*	8.6%	6.7%
Oak	*Quercus petrae (Matt.) Liebl. , Q. robur L.*	7.4%	5.4%
Longlived broadleaves	*Tilia cordata Mill., Tilia platyphyllos Scop., Fraxinus excelsior L., Acer pseudoplatanus L., Carpinus betulus L.*	6.1%	4.0%
Shortlived broadleaves	*Betula pendula Roth., Alnus glutinosa (L.) Gaertn., Populus spp., Alnus incana (L.) Moench*	5.3%	2.6%
Fir	*Abies alba Mill., Pseudotsuga menziesii (Mirb.) Franco*	1.4%	1.5%
Clearing, gap	Temporarily unforested area, e.g. after clear-cut.	1.4%	-
Spruce snag	Additional forest type representing dead spruce forest due to water stress and bark-beetle mortality.	-	-

The applicable harvest used for the scenario With existing measures (WEM) corresponds in principle to the BLACK scenario as in the Czech NFAP[4] (WEM scenario details see in Section 2.5.1.2 below).

[4] https://www.mzp.cz/C1257458002F0DC7/cz/opatreni_v_ramci_lulucf/$FILE/OEOK-CZ_NFAP_FRL_final-20200203.pdf

However, the applicable harvest volumes were based on the available stock for individual harvest categories for each forest type (Albert et al., 2020 – in prep.). The harvest categories include thinning, salvage logging and planned final cut. At the same time, both the amount and proportion of salvage and planned logging was regionally specific, based on the available information on forestation (Fig. 2-76) and forest dieback applicable to spruce stands. Harvest volumes is derived for two regimes, one is dominated by salvaging, while the other represents the ordinary planned management with limited salvage. Salvage regime is based on the most recent know data (in 2018-2019), which set the amount of harvest for salvage-dominated period. For the following planned management, harvest is determined by wood available to harvest by age classes, forest type (Tab. 2-7) and felling type (thinning, final cut, salvage). For this regime, harvest rate meets the sustainability requirement as prescribed in the Czech Forest Act. The harvest includes the share of so-called unregistered felling volumes, which represent the harvest residues extracted in individual years as reported by the Czech Statistical Office (CzSO), in the same manner as adopted in the emission inventory estimates for 4.A Forest land. As for thinning, its quantity depends on the intensity of salvaging and development of age class structure for individual forest types within each region. For the year with extreme salvage felling, the share of planned thinning is fragmental, ca. 2%, whereas it gradually increases up to 38 % once the effect of spruce forest dieback diminishes, planned management dominates over the residual salvaging and the share of younger stands requiring thinning increases. Finally to note, during the period of extreme dieback, the technical harvest capacities in the country are insufficient for a complete harvest of infected and/or dead standing trees, which is in normal conditions mandatory under the Czech Forest Act. This is considered and the harvest quantities of left-over dead trees are specifically accounted for. The harvest demand composed in his way and summarized by planned and sanitary operations is shown in Tab. 2-483048.

Tab. 2-4830 Harvest volumes used to drive CBM-CFS3 model run for particular years, together with the expressed share of thinning by volume.

	Harvest (Mm³/year)				Thinning share
Period	Planned	Sanitary	Left-over dead trees	Total removals	By volume (%)
2018	2.65	22.80		25.46	0.04
2019	1.62	30.45		32.07	0.02
2020	1.56	30.45	1.02	33.03	0.02
2025	3.79	19.04		22.83	0.09
2030	4.58	15.05		19.63	0.14
2035	6.16	10.84		17.00	0.22
2040	7.86	7.30		15.16	0.32
2045	8.55	7.44		15.99	0.33
2050	9.37	6.50		15.87	0.38

Note: Leftover dead trees are applicable for period 2020 - 2024

Linked to sanitary felling and planned final cut, the model run incorporates gradual changes of species composition for new planting/regeneration, which is based on the actually reported data (2018) and the specific scenario assumptions (Section 2.5.1.2 below).

The projections of GHG emissions related to other land use categories besides 4.A Forest land (i.e., 4.B Cropland, 4.C Grassland, 4.D Wetlands, 4.E Settlements) are based on simple correlations of the estimated emissions for the reference year linked exclusively to the corresponding land areas for the predicted years. The exception is the emission contribution of 4.G HWP, which are newly reported under UNFCCC and Kyoto Protocol since the 2015 annual national inventory submission.

Finally, the contribution of 4.G HWP was projected using the harvest activity data as reported in NIR (CHMI, 2020). For the period from 2019 to 2050, harvest volumes (logs) as adopted for the EFISCEN-assisted estimates, were used as input and proxy for estimation of 4.G HWP contribution following the identical methodology for 4.G HWP as described in NIR (CHMI, 2020), and projection in accordance with the approach detailed in the Czech NFAP[5].

Tab. 2-49 Summary of the methodological approaches used for the 4. LULUCF categories

Activity data and category	Approaches
Land use areas for individual land use categories	COSMC data for 1990 - 2018, thereon projections until 2050 using - linear trend (4.D Wetlands), sustained rate - non-linear/sigmoidal trend (4.E Settlements), sustained rate - non-linear/sigmoidal trend (4.A Forest land, 4.B Cropland, 4.C Grassland), half-reduced trend relative to 1990 – 2018
Emission estimates for 4.A Forest land	NIR data for 1990 - 2018 (CHMI 2020), thereon projections using CBM-CFS3 model version 1.2 (Kull et al. 2016), with ex-ante adjustment for change in 4.A Forest land area.
Emission estimates for other land use categories except 4.A Forest land	NIR data for 1990 - 2018 (CHMI 2020), thereon a rescaled reference data from 2015 using projected land area as a proxy for individual land-use categories
4.G HWP contribution	Production approach as in NIR 1990 - 2018 (CHMI 2020), thereon estimates until 2050 using harvest demand (logs) as applied for the EFISCEN-assisted projections, identically for WEM and WAM scenarios

Definition of 'With existing measures' (WEM) and 'With additional measures' (WAM) scenario

The WEM scenario includes the development of land areas of individual land use categories as shown in Tab. 2-6 and Fig. 2-54. Land area is used as a proxy for the projected emissions. Hence, development of land areas and land use changes drive the projected emissions relative to the reference year (2018) for the individual land use categories with exception of CO_2 emissions from 4.A Forest land and HPW emission contribution (Tab. 2-49).

For 4.A Forest land, the entire WEM scenario concept was redesigned to address the recent catastrophic decline of coniferous stands due to drought-induced bark-beetle infestation. Also, the newly adopted modelling toll, the CBM-CFS3 model v1.2 (Kull et al., 2016), permitted a more detailed representation of processes associated with both management of disturbed managed forest ecosystems. The WEM scenario includes the currently implemented forest management recommendations (age-specific thinning and felling per forest types) of the Czech Forest Act and actual species composition in the reference year. At the same time, salvage felling is mandatorily prioritized over the planned management interventions, which is in full accordance with the valid legislation – Czech Forest Act and its amendments.

Specifically, the currently defined WEM scenario for forestry assumes spruce share to decline from the current (in 2018) share by a range starting at about 50% to 25% or less until 2050. Correspondingly, the share of broadleaved tree species would increase. This is in line with the long-term adaptation strategy of the country (Krejza, 2008) (Cienciala, 2012) (MoE, 2017), which includes the proposed tree species change of dominantly spruce even-aged forests stand to more diverse stands with higher share of broadleaved tree species such as beech and oak. The assumed species conversion under the current WEM scenario would be significantly accelerated by the ongoing forest decline. The felling request is defined as follows: 32.6 mill. m^3/year for the outbreak regime (based on the reported data by CzSO for

[5] https://www.mzp.cz/C1257458002F0DC7/cz/opatreni_v_ramci_lulucf/$FILE/OEOK-CZ_NFAP_FRL_final-20200203.pdf

2019, while the harvest volume for the following projection years is determined interactively using the CBM-CSF3 model operating at the level of regions and forest type, based on wood available for harvest by individual harvest categories (Tab. 2-483048).

It should be understood, however, that in the conditions of the current outbreak and share of sanitary felling of 95 % (in 2019), the Czech forest management resembles a crisis management instead of the conventionally planned activity guided by forest management plans with duration of 10 years. Hence, the current forest development is dominantly driven by disturbance (drought and bark-beetle infestation) and any projection of forest resources will inherently be very uncertain. This justifies using one single WEM scenario, whereas any additional pragmatically implementable management intervention under any WAM scenario would likely not have effects larger than uncertainties associated with addressing and development of the current unprecedented disturbance to forestry. Therefore, no WAM scenario is elaborated in this material.

2.5.1.2. Projected GHG emissions 'With existing measures' (WEM) scenario

The historical data and projections using the WEM scenario are shown in Tab. 2-310 and

Fig. 2-88. It can be observed that for the nearest projected period, the 4. LULUCF sector is projected to significantly contribute to GHG emissions in the country. The projection follows the reported year 2018 (CHMI, 2020), which reported 4. LULUCF to be an emission source for the first time for the entire reporting period since 1990. The emissions became even higher in 2019 (IFER 2020 - unpublished data). This is practically exclusively due to the development on 4.A Forest land under the assumed harvest demand for the adopted WEM scenario. As explained earlier, harvest level in the Czech forestry is currently dominated my mandatorily prioritized salvage felling of declining coniferous stands.

The essence of the presented emission trend under the revised WEM scenarios can be interpreted as follows:

- The Czech forestry is experiencing an unprecedented outbreak of bark-beetle infestation and associated dieback of spruce (and in minor scale also pine) stands. This results in rapidly increasing share of sanitary felling.
- Even though the planned felling is restricted to minimum, the rising share of sanitary logging has resulted in overall record-high felling volumes in 2018 and 2019 (CzSO). It is expected that the felling level in 2020 would equal or surpass that in 2019 (Tab. 2-483048).
- In the coming decade until 2030, the harvest level would gradually decline, which would turn emissions of the 4. LULUCF sector into a sink of emissions at the latest by the year 2030.
- For the last two projected decades (2031-2050), the harvest would decrease to about 16 mil. m^3 wood volume per year, which would be below the projected increment in forestry. This would mean creating a significant sink of emissions, making the entire 4. LULUCF sector GHG sink category in the national circumstances.
- The WEM scenario as presented in this submission represents an adaptive scenario for the Czech forestry. It will result in a more rapid conversion of productive, but instable coniferous stands into a more resilient, dominantly broadleaved and/or mixed forest stands. This is the desired direction of forest transition under the adaptation strategies as adopted in the country (MoE, 2017). The historically strong decline of coniferous stands as witnessed today should result in a faster change leading to more resilient, adapted forest stands fulfilling all expected functions and services, including water retention, soil protection, recreation and wood production, as well as climate mitigation. A significantly larger share of broadleaved tree species will be used (Fig. 2-7).
- As for the productive function of forest, it is expected that volume production would not reach the levels as witnessed for the first two decades of this century. However, an overall

production "security" should increase, and the frequency of undesired disturbances decrease, which would favor both wood production and other forest functions and services in general.

- The overall importance of wood harvest volume drain on emission balance in 4. LULUCF sector is demonstrated with sensitivity analysis using changed harvest levels (Fig. 2-90). Evidently, any disturbance to forests leading to elevated harvest volume levels would negatively affect carbon balance in the sector.

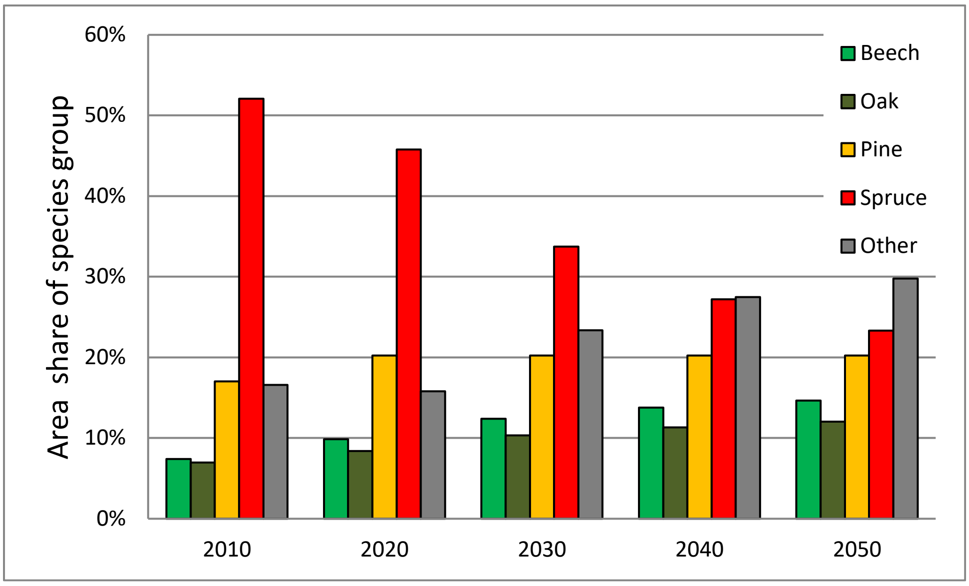


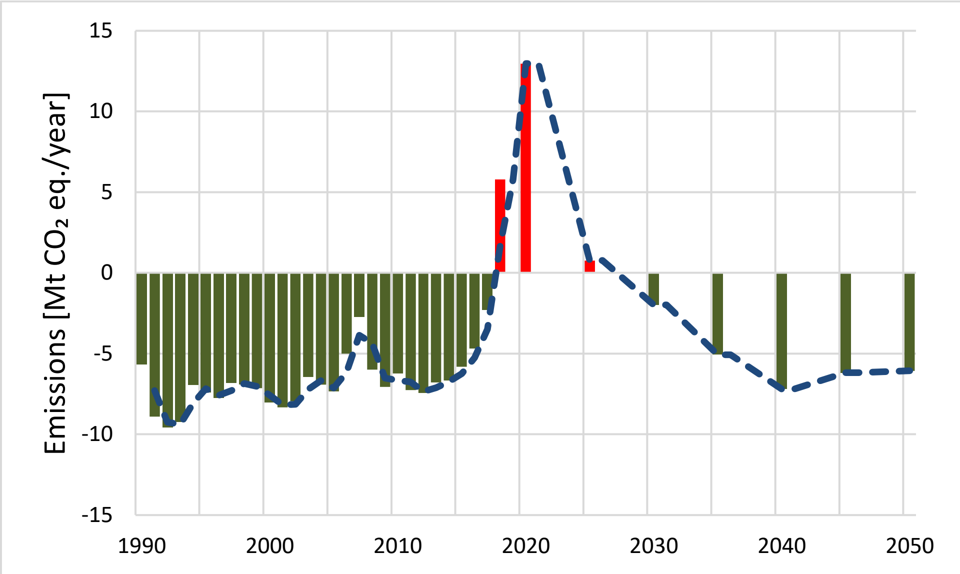
Fig. 2-17 Historical (2010) and projected (2020 - 2050) tree species composition within the WEM scenario, expressed by the share of the forest area occupied by the individual species groups. There is a notable decline of spruce species group, compensated by an increased share of dominantly broadleaved forest types (including the group Other, which is dominantly composed by broadleaves).

Tab. 2-310 Reported and projected emissions of GHG in 4. LULUCF sector – WEM scenario

	Reported emissions			Projected emissions				Difference			
[Mt CO_2 eq.]	**1990**	**2015**	**2018**	**2020**	**2030**	**2040**	**2050**	**1990 – 2020**	**1990 – 2030**	**1990 – 2040**	**1990 – 2050**
WEM	-5.69	-5.81	5.79	13.0	-1.98	-7.19	-6.07	18.6	3.70	-1.51	-0.39

(CHMI, 2020)

Fig. 2-88 Reported and projected emissions of GHG in 4. LULUCF sector for WEM scenario. The historical data (until 2018) and projection until 2050 is overlayed by a 2-yrs moving average line.



(CHMI, 2020)

The breakdown of historical and projected (WEM scenario) emissions by gases and individual land use categories is shown in Tab. 2-321 and Tab. 2-332, including the individual 4. LULUCF categories. The emissions in the 4. LULUCF sector are mostly determined by carbon stock changes in the category 4.A Forest land and partly by the newly reported contribution of 4.G HWP. For the interpretation of the estimated emission levels trends in 4.A under WEM, see the lead text in chapter 2.5.1.2

Tab. 2-321 Breakdown of reported and projected emissions of GHG by gases in 4. LULUCF sector - WEM scenario

[Mt CO_2 eq.]	Reported emissions			Projected emissions				Difference			
	1990	2015	2018	2020	2030	2040	2050	2020–1990	2030–1990	2040–1990	2050–1990
CO_2	-5.77	-5.87	5.75	12.9	-2.04	-7.25	-6.13	18.7	3.73	-1.48	-0.36
CH_4	0.04	0.03	0.02	0.03	0.03	0.03	0.03	-0.01	-0.01	-0.01	-0.01
N_2O	0.04	0.03	0.02	0.03	0.03	0.03	0.03	-0.01	-0.01	-0.01	-0.01
Total	**-5.69**	**-5.81**	**5.79**	**13.0**	**-1.98**	**-7.19**	**-6.07**	**18.6**	**3.70**	**-1.51**	**-0.39**

(CHMI, 2020)

Tab. 2-332 Breakdown of reported and projected emissions of GHG by categories in 4. LULUCF sector - WEM scenario

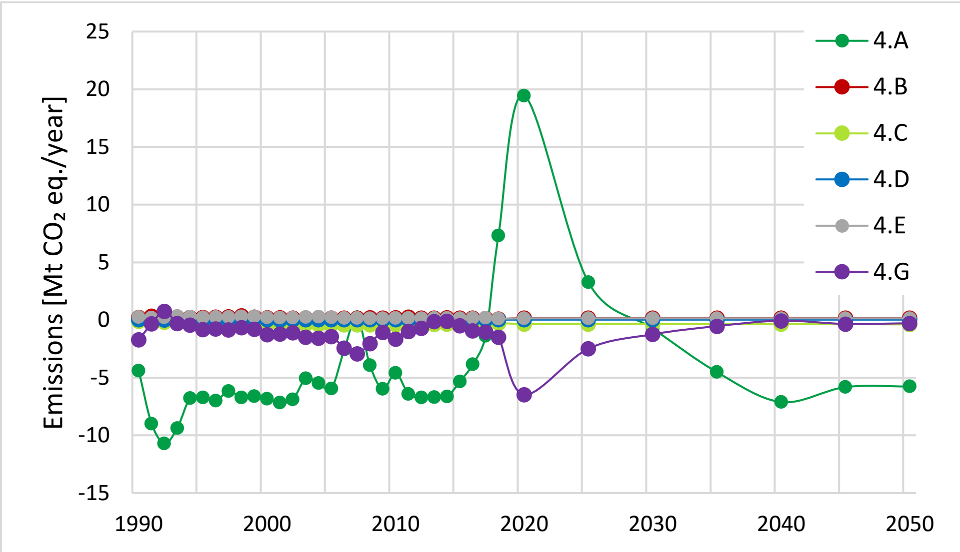
[Mt CO_2 eq.]	Reported emissions			Projected emissions				Difference			
	1990	2015	2018	2020	2030	2040	2050	2020–1990	2030–1990	2040–1990	2050–1990
4.A Forest land	-4.37	-5.32	7.32	19.5	-0.71	-7.10	-5.75	23.8	3.66	-2.72	-1.38
4.B. Cropland	0.21	0.17	0.10	0.16	0.16	0.16	0.16	-0.05	-0.05	-0.06	-0.06
4.C Grassland	-0.11	-0.34	-0.28	-0.37	-0.36	-0.36	-0.37	-0.24	-0.25	-0.25	-0.26
4.D Wetlands	0.02	0.03	0.02	0.03	0.03	0.03	0.03	0.00	0.00	0.01	0.01
4.E Settlements	0.27	0.14	0.12	0.15	0.15	0.15	0.15	-0.13	-0.12	-0.12	-0.12

4.G HWP	-1.71	-0.49	-1.49	-6.48	-1.25	-0.07	-0.29	-4.77	0.46	1.64	1.42
Total	**-5.69**	**-5.81**	**5.79**	**13.0**	**-1.98**	**-7.19**	**-6.07**	**18.7**	**3.70**	**-1.51**	**-0.39**

(CHMI 2020)

The quantitative share and trends of emissions under WEM scenario by individual 4. LULUCF categories shows Fig. 2-19. Prominently, the category 4.A Forest land dominates in both historical period until 2018 and during the projected period until 2050, followed by the 4.G HWP contribution.

Fig. 2-19 Breakdown of reported and projected (WEM scenario) emissions of GHG by land-use categories within 4. LULUCF, namely Forest land (CRF 4.A), Cropland (CRF 4.B), Grassland (CRF 4.C), Wetlands (CRF 4.D) and Settlements (CRF 4.E), plus the quantified HWP contribution (CRF 4.G).



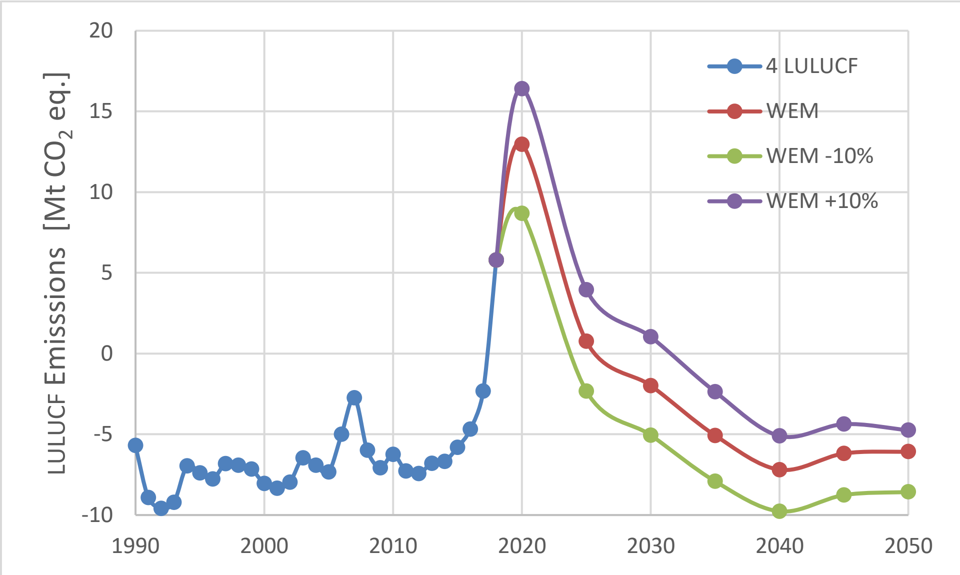
(CHMI, 2020)

2.5.1.3. Sensitivity analysis

Sensitivity analysis is conducted by analyzing the changes effect of harvest on the total emissions of the 4. LULUCF sector. Harvest level affects emissions of the land use category 4.A Forest land, and correspondingly also 4.G HWP contribution. These are the key categories of the Czech emission inventory, determined by biomass carbon stock changes in the sub-category 4.A.1 Land remaining Forest land and the stocks of 4.G HWP. Harvest intensity basically represents the entire forest management in the country and its effect on forest growing stock volume and ecosystem carbon stock. Here, the loss is determined by harvest removals including thinning and final felling. This is offset by annual biomass increment. Therefore, harvest regime is the most prominent factor affecting carbon balance in the sector.

The role of harvest quantity is demonstrated on the sensitivity analysis using smaller or larger overall harvest demand by 10% with respect to the selected baseline (harvest as in WEM scenario) using the CBM-CSF3 model. The model outcome as implemented for the WEM scenario and its two variants is shown in Fig. 2-90. It is apparent that a relatively small change in harvest demand would have a significant effect on greenhouse gas emissions from the 4. LULUCF sector. It should also be noted that harvest demand is a more powerful short-term factor affecting emissions as compared to gradual tree species change as implemented in the WEM scenario and affects carbon balance more on long-term basis.

Fig. 2-90 Sensitivity analysis using variable harvest demand and its effect on emissions in 4. LULUCF under WEM scenario



2.5.1.1. Difference between previously and currently reported projections

There is no fundamental methodological difference in the concept of the 4. LULUCF projections, but the tool used for quantifying the emissions for 4.A Forest land changed. This submission used CBM-CSF3 model, while previously, EFISCEN was used for projecting forest resource and the associated ecosystem carbon balance. The details and references to these models are given in Section 2.5.1 above.

Much more fundamental change represents the recent tragic development in the Czech forestry, which experiences an unprecedented drought-induced decline of coniferous forest stands, with an exceptional bark-beetle outbreak. The associated increase of salvage logging turned 4.A Forest land and the entire 4. LULUCF sector into a significant GHG source in 2018 (CHMI, 2020). This is for the first time during the reporting period since 1990. As of late 2020, it is known that emissions from 4.A further increased during 2019 (Emil Cienciala, unpublished data). This information, specifically the harvest levels (Tab. 2-483048) naturally affected the construction of the WEM scenario as elaborated in the current text.

2.6. Waste

The 5. Waste sector in the Czech Republic can be separated to four distinctive source categories. First, so far dominant category is 5.A Solid waste disposal, which is a primary source of CH_4 emissions. Emissions of CO_2 from 5.A are of a biogenic origin and therefore, not included to the projected emissions. Category 5.B Biological treatment of waste is a source category which consists of composting and anaerobic waste digestion. As composting is aerobic process and anaerobic digestion is technologically controlled process, emissions from this source category tend to be negligible, even when this category seems to be growing in the Czech Republic. Emissions from use of biogas produced in anaerobic digestion are not part of this source category, as they are part of category 1.A Energy. However, emissions leakage from digestion process is accounted for. Emissions form category 5.C Waste incineration are accounted in 1.A Energy sector, when it produces useable energy. Only hazardous and industrial 5.C Waste incineration is accounted for in 5.C, which is the same approach as in the National Inventory Report (NIR) (CHMI 2020). Waste incineration (5.C) produces all the three major greenhouse gasses (GHG), but predominantly it's a fossil CO_2 source. The last category, 5.D Wastewater treatment, includes both public and private wastewater treatment plants as well as industrial counterparts and it is a source of CH_4 and N_2O emissions. In 2018, the total aggregate GHG emissions from 5.Waste were 5, 704.49 kt CO_2 eq., which represent increase of 83% compared to 1990. GHG emissions trend from the 5. Waste sector is depicted in Fig. 2-10 (CHMI, 2020).

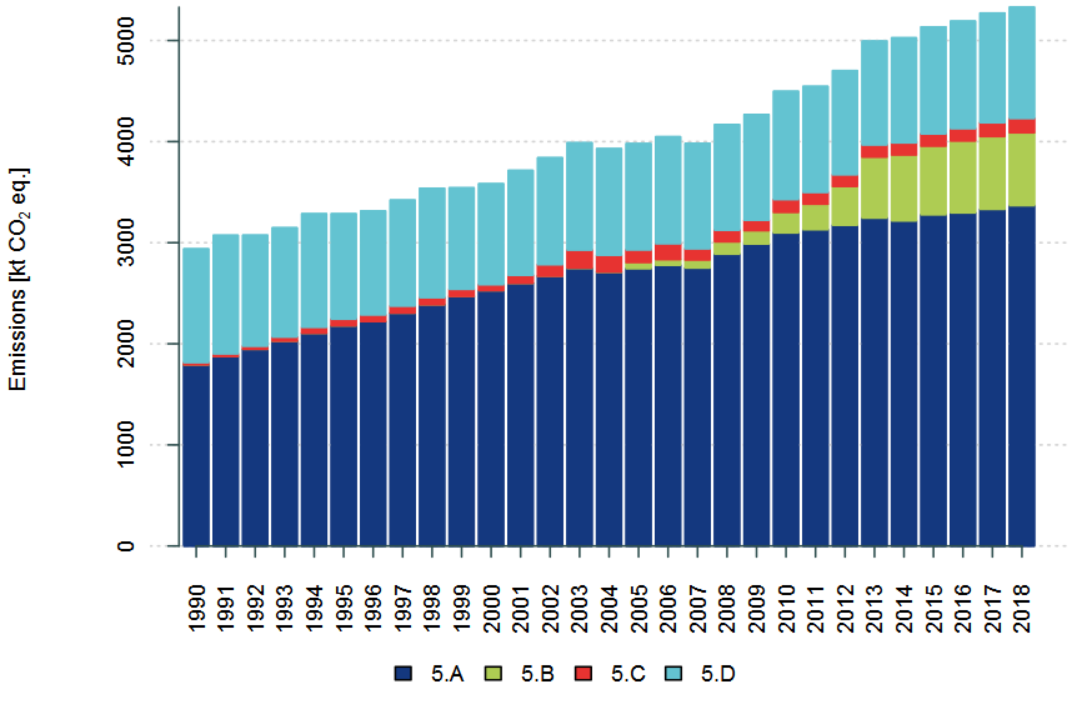


Fig. 2-10 The emission trend in 5. Waste sector during the reporting period 1990 - 2018

Tab. 2-343 The emissions in 5. Waste sector during the reporting period 1990 - 2018

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Mt CO2 eq.	3.12	3.27	3.28	3.36	3.50	3.51	3.55	3.67	3.79	3.81	3.85	3.99	3.13	4.29	4.23
Year	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	
Mt CO2 eq.	4.29	4.37	4.31	4.51	4.62	4.86	4.92	5.08	5.37	5.40	5.51	5.57	5.65	5.70	

Overall development of the 5. Waste sector in the past decades is dominated by landfilling of waste in Solid Waste Disposal Sites (SWDS). Landfilling is still dominant type of waste management, but its importance is decreasing due to rise of waste recycling; collection of separated waste parts, composting and energy recovery. In not so distant future, landfilling (mainly of municipal (MW) and organic waste) might disappear as the capacity of landfills is decreasing and other options are preferred by national legislation and obligations of the Circular Economy Package (CEP) (EC, 2018). However, the steady increase in energy recovery and even the impressive leaps in composting and material recovery during the past four years did not lead to a decrease in landfill due to a steady increase in total amount of MW (CHMI 2020).

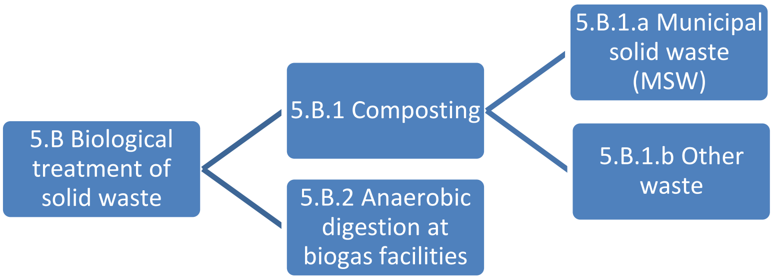
Waste sector (5.) has high uncertainty in regards to emission levels as many of processes behind the emissions are either not sufficiently understood or are strongly dependent on local conditions which makes top down assessment such as this very difficult. Furthermore, 5. Waste sector is ultimate end point of all consumption and economic activity and therefore, it is also highly dependent of the whole economy setting, which makes it even harder to predict. Default uncertainty for the GHG emission levels in 5. Waste sector are around +/-40%, with some source subcategories reaching to the factor of two. This uncertainty originates mainly from emission factors. Activity data is also uncertain, but due to economic nature of waste management it is regularly scrutinised and controlled (CHMI, 2020).

2.6.1.1. Methodological issues

The projections of GHG emissions in 5. Waste sector are based on data and methodology used for emission estimates reported in NIR (CHMI, 2020). Activity data reported in NIR (CHMI, 2020) are obtained from the Czech official database of waste management VISOH ("Veřejné informace o produkci a nakládání s odpady"). The adapted spreadsheets used for NIR (CHMI 2020) were used to extend the time series for all the sectors, except 5.D Wastewater treatment and discharge, where the timelines for CH_4 and N_2O emissions were extended straight from the recent year (2018) emission values.

Emissions, activity data and parameters up to current reporting year are from the common reporting format (CRF) and VISOH. From 2018 to 2050, extended time series were aligned with assumptions from the Waste Management Plan 2014 (WMP) (MoE, 2014) and by the obligations of the CEP (EC, 2018). The forecasted scenario in the WMP (MoE, 2014) was the guiding pathway for updating the projections.

First the assumptions and landfilling data from WMP (MoE, 2014), for 5.A Solid waste disposal, have to be explained, in order to show transparently steps for estimating category 5.A Solid waste disposal emission. The difference between the With existing measures (WEM) and With additional measures (WAM) scenarios is increased recovery of landfill gas, which is increasing more sharply in WAM scenario due to increased pressure from renewables market. The WAM scenario has higher projected trend for recovered landfill gas (LFG) than WEM from 2025. Recovered CH_4 from LFG is used for energy purposes and is subtracted from total emissions (CHMI, 2020). The projected trend of emissions from category 5.A is thus, decreasing steeply after 2025 (see Tab. 2-59).



Wet weight data and default emission factors (EF) 4 kg CH_4/t and 0.24 kg N_2O/t from IPCC 2006 GL (IPCC, 2006) were used for both subcategories (5.B.1 and 5.B.2). Activity data values in NIR 5.B.1 spreadsheet were extended up to 2050 by linear extrapolation. This category took big annual leaps in the past, but the latest reductions in increase were reflected in the estimates. For the subcategory 5.B.2 Anaerobic digestion at biogas facilities, a default 5% leakage (an average from 2013 – 2018) was included as a constant to the entire forecast. The leakage amounted to 0.6 Mt CO_2 eq. The projected trend of emissions from category 5.B is slightly increasing between 2018 and 2050 (Tab. 2-59).

The category 5.C Incineration and open burning of waste includes only waste that is not used for energy production. Estimation of CO_2 emissions from hazardous/industrial waste (H/IW) incineration is based on the Tier 1 approach (IPCC, 2006] (CHMI, 2020). Incinerated H/IW was extrapolated until 2050 and the results were inserted into the spreadsheet to get emission forecast for CO_2, CH_4 and N_2O until 2050. The default emission factors used for projections (0.56 kg CH_4/Gg and 100 kg N_2O/Gg) are from the IPCC 2006 GL (IPCC, 2006). The projected H/IW is within the existing incineration capacity. The projected trend of emissions from category 5.C is increasing slightly between 2018 and 2050 (Tab. 2-).

In the category 5.D Wastewater treatment and discharge, the method is based on default Tier 1 and EFs used for projection are also default from the IPCC 2006 GL (IPCC, 2006) (CHMI, 2018). Timelines for CH_4 and N_2O emissions were extrapolated until 2050 by multiplying 10-year average of N_2O Implied emission factor (IEF) and CH_4 IEF with the population estimates from Eurostat (2020). The projected trend of emissions from 5.D is slightly decreasing between 2018 and 2050 (Tab. 2-).

Tab. 2-354 Reported and projected MMW production, divided by subjects in the Czech Republic

[Mil. Tons]	Reported							Projected				
	2013	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**
Municipalities	1.54	1.84	1.86	2.18	2.18	2.27	2.46	2.27	2.22	2.17	2.12	2.07
Non-municipal entities	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Total	**2.44**	**2.74**	**2.76**	**3.08**	**3.08**	**3.17**	**3.36**	**3.17**	**3.12**	**3.07**	**3.02**	**2.97**

(MoE 2014, CHMI 2020)

Tab. 2-365 Reported and projected MW management

[Mt]	Reported							Projected				
	2013	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**
Material recovery	1.56	1.85	1.88	2.14	2.14	2.23	2.41	2.46	2.50	2.55	2.60	2.64
Composting	0.20	0.30	0.37	0.58	0.62	0.64	0.66	0.69	0.71	0.74	0.76	0.79
Energy recovery	0.61	0.63	0.62	0.68	0.69	0.68	0.69	0.71	0.74	0.76	0.78	0.81
Landfill	2.96	2.83	2.76	2.78	2.84	2.92	2.96	2.49	2.29	2.10	1.90	1.70
Incineration	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02

(MoE, 2014) (CHMI, 2020)

Tab. 2-376 Detailed information about methodology assumptions used in projections for 5. Waste sector (sub-)categories

	Projections 2019- 2050		
Category	**Activity data**	**EFs**	**Methodology**
5.A Solid waste disposal on land	to 2018 obtained from NIR (CHMI 2020) and VISOH database, linear extrapolation was aligned with the WMP (MoE 2014) and CEP (EC 2018) assumptions.	Default	Tier 1
5.B Biological treatment of solid waste	to 2018 obtained from NIR (CHMI 2020) and VISOH database, linear extrapolation was aligned with the WMP (MoE14) and CEP (EC 2018) assumptions.	Default	Tier 1
5.C Incineration and open burning of waste	to 2018 obtained from NIR (CHMI 2020) and VISOH database, linear extrapolation was aligned with the WMP (MoE14) and CEP (EC 2018) assumptions.	Default	Tier 1
5.D Wastewater treatment and discharge	to 2018 obtained from NIR (CHMI 2020) and VISOH database, extrapolation to 2050 was aligned with the projected trend of population from the Eurostat (Eurostat 2020).	Default	Tier 1

(CHMI, 2020) (IPCC, 2006)

2.6.1.2. Projected greenhouse gas emissions 'With existing measures (WEM) scenario' and 'With additional measures (WAM) scenario'

As indicated in Tab. 2-386, emission estimates up to the latest reported year (2018) are from NIR (CHMI, 2020) and VISOH database. Timeline was prolonged up to 2050 by building upon the outlined scenario in WMP (MoE 2014) and by the new obligations of the CEP (EC, 2018).

Scenario in WMP (MoE, 2014) fulfils description of WEM scenario, the document is taking into account all measures that are already in effect, although further measures will be implemented in the future, based on the roadmap proposed in WMP. For both WEM and WAM scenarios it is expected that emissions will be decreasing for 2020 - 2050, compared to 2018. Decrease of emissions is more obvious for WAM scenario which takes into account stricter LFG recovery coefficients after 2025. The expected total emissions from 5. Waste should decrease by -6.50% according WEM and decrease by -15.25% according WAM between 1990 and 2050. Overall results for the 5. Waste sector are shown in Tab. 2-397. Reported and projected emission trend for both scenarios is depicted in Fig. 2-11 below.

Tab. 2-397 Reported and projected emissions of GHG in 5. Waste – WEM and WAM scenarios

	Reported emissions			Projected emissions							Difference [%]			
[Mt CO_2 eq.]	**1990**	**2005**	**2018**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**	**1990 – 2020**	**1990 – 2030**	**1990 – 2040**	**1990 – 2050**
WEM	3.12	4.29	5.70	566	5.33	4.65	3.84	3.35	3.08	2.92	81.07	48.95	7.30	-6.50
WAM	3.12	4.29	570	5.66	5.26	4.59	3.77	3.21	2.87	2.65	81.07	46.76	2.87	-15.25

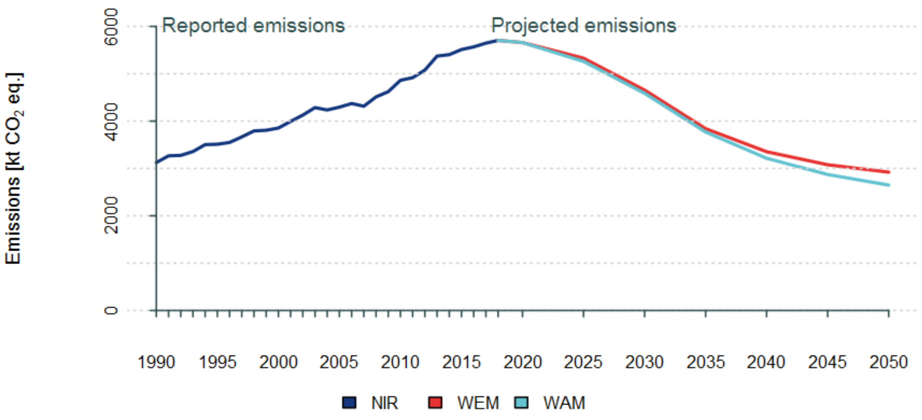


Fig. 2-11 Reported and projected emissions of GHG in 5. Waste – WEM and WAM scenarios

Projected greenhouse gas emissions 'With existing measures (WEM) scenario'

Development of the WEM scenario is based on following assumptions: MW production is decreasing slightly, landfilling is gradually declining and composting and energy recovery is taking place instead (MoE, 2014) within the 10% landfill limit by 2035 as per CEP (EC, 2018). The shift from landfilling to composting and anaerobic digestion decreases overall emissions, because composting and anaerobic digestion produce lower emissions. As landfilling decreases, a slight increase of emissions can be observed in 5.B Biological treatment of solid waste due the default 5% leakage from anaerobic digestion, which was 0.6 Mt in 2018, and due the effects of establishing a mandatory system for separate collection of biodegradable waste and its waste management.

The shift from landfilling to 5.C Waste incineration is less visible here, as waste used for energy is reported under 1.A Energy sector, where it does not leave a significant footprint when compared to the size of 1.A Energy sector. Detailed breakdown of the emissions by gases and categories is shown in Tab. 2-5840 and Tab. 2-.

Tab. 2-5840 Breakdown of reported and projected emissions of GHG by gases in 5. Waste - WEM scenario

[Mt CO_2 eq.]	Reported emissions			Projected emissions							Difference [%]			
	1990	2005	2018	2020	2025	2030	2035	2040	2045	2050	1990 – 2020	1990 – 2030	1990 – 2040	1990 – 2050
CO_2	0.02	0.12	0.11	0.14	0.16	0.17	0.19	0.21	2.22	0.24	574.39	735.04	895.69	1056.34
CH_4	2.87	393	5.30	5.24	4.88	4.18	3.34	283	2.53	2.34	82.72	45.78	-1.42	-18.29
N_2O	0.23	0.24	0.26	0.27	0.29	0.30	0.31	0.32	0.33	0.34	17.00	26.83	35.07	39.19
Total	**3.12**	**4.29**	**5.70**	**5.66**	**5.33**	**4.65**	**3.84**	**335**	**3.08**	**2.92**	**81.07**	**48.95**	**7.30**	**-6.50**

Tab. 2-59 Breakdown of reported and projected emissions of GHG by categories in 5. Waste - WEM scenario

[Mt CO_2 eq.]	Reported emissions			Projected emissions							Difference [%]			
	1990	2005	2018	2020	2025	2030	2035	2040	2045	2050	1990 – 2020	1990 – 2030	1990 – 2040	1990 – 2050
5.A Solid waste disposal	1.98	3.06	3.74	3.72	334	2.63	1.79	1.27	0.97	0.78	87.80	33.03	-35.80	-60.63
5.B Biological treatment of solid waste	NO/IE	0.06	0.72	0.73	0.76	0.79	0.82	0.85	0.88	0.91	NA	NA	NA	NA
5.C Incineration and open burning of waste	0.02	0.12	0.14	0.14	0.16	0.18	0.19	0.21	0.23	0.24	571.85	731.90	891.95	1052.0
5.D Waste water treatment and	1.12	1.05	1.10	1.07	1.07	1.06	1.04	1.02	1.01	0.99	-4.80	-6.01	-8.97	-11.99

discharge														
5.E Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Total	**3.12**	**4.29**	**5.70**	**5.66**	**5.33**	**4.65**	**3.84**	**3.35**	**3.08**	**2.92**	**81.07**	**48.95**	**7.30**	**-6.50**

Projected greenhouse gas emissions 'With additional measures (WAM) scenario'

WAM scenario is almost identical to WEM scenario because all planned changes in waste management practice are implemented according to the WMP (MoE, 2014) and by the new obligations of the CEP (EC, 2018). The difference between WEM and WAM scenarios is an increased recovery of landfill gas, which is raising more sharply in WAM scenario due to amplified pressure from renewables market. The effects can be observed in CH_4 values (Tab. 2-60) and in 5.A Solid waste disposal category (Tab 2-61). Total amount of emissions is reduced by 15.25% compared to 6.50% decrease in WEM scenario from the base year 1990 until 2050. Breakdown by gases and source categories is shown in Tab. 2-0 and Tab. 2-411.

Tab. 2-60 Breakdown of reported and projected emissions of GHG by gases in 5. Waste - WAM scenario

[Mt CO_2 eq.]	Reported emissions			Projected emissions							Difference [%]			
	1990	2005	2018	2020	2025	2030	2035	2040	2045	2050	1990 – 2020	1990 – 2030	1990 – 2040	1990 – 2050
CO_2	0.02	0.12	0.14	0.14	0.16	0.17	0.19	0.21	0.22	0.24	574.39	735.04	895.69	1056.34
CH_4	2.87	393	5.30	5.24	4.82	4.11	3.27	2.69	2.32	2.07	82.72	43.39	-6.24	-27.81
N_2O	0.23	0.24	0.27	0.27	0.29	0.30	0.31	0.32	0.33	0.34	17.00	26.83	35.07	43.27
Total	**3.12**	**4.29**	**5.70**	**5.66**	**5.26**	**4.59**	**3.77**	**3.21**	**2.87**	**2.65**	**81.07**	**46.76**	**2.87**	-15.25

Tab. 2-411 Breakdown of reported and projected emissions of GHG by categories in 5. Waste - WAM scenario

[Mt CO_2 eq.]	Reported emissions			Projected emissions							Difference [%]			
	1990	2005	2018	2020	2025	2030	2035	2040	2045	2050	1990 – 2020	1990 – 2030	1990 – 2040	1990 – 2050
5.A Solid waste disposal	1.98	3.06	3.74	3.72	3.27	2.56	172	1.13	076	0.51	87.80	29.57	-42.78	-74.43
5.B Biological treatment of solid waste	NO/IE	0.06	0.72	0.73	0.76	0.79	0.82	0.85	0.88	0.91	NA	NA	NA	NA
5.C Incineration and open burning of waste	0.02	0.12	0.14	0.14	0.16	0.18	0.19	0.21	0.23	0.24	571.85	731.90	891.95	1052.0
5.D Waste water treatment and discharge	1.12	1.05	1.10	1.07	1.07	1.06	1.04	1.02	1.01	0.99	-4.80	-6.01	-8.97	-11.99
5.E Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Total	**3.12**	**4.29**	**5.70**	**5.66**	**5.26**	**4.59**	**377**	**3.21**	**2.87**	**2.65**	**81.07**	**46.76**	**2.87**	**-15.25**

2.6.1.3. Sensitivity analysis

Projections of GHG emissions from 5. Waste sector are based on calculation sheets used for emission estimates in NIR (CHMI 2020). Activity data is only variable which changes during 2018 – 2050 (see chapter 2.6 for detailed information about projections of activity data). EFs are constant during the projected period and thus, sensitivity analysis would not bring any interesting outcomes. If activity data will change by ±5% then emissions will change by ±5% because EFs used for emission estimates are constant during the projected period.

2.6.1.4. Difference between previously and currently reported projections

In category 5.A Solid waste disposal, NIR (CHMI, 2020) and VISOH indicate 2.9 Mt of landfill MW in 2019, making the previously applied 1.9Mt for 2020 from the WMP (MoE, 2014) infeasible for use in projections. 1 Mt drop in landfill waste is not foreseen in a single year 2020. Instead of using direct values from the WMP (MoE, 2014), linear extrapolation was aligned with the same WMP (MoE, 2014) assumptions that MW total will decrease slightly, landfilling can be reduced to a small amount or phased out completely by 2030 or soon after, and with CEP assumption that max 10% from total MW by 2030 is allowed to be landfilled. CH_4 emissions increased as a result of the new estimations. Impact of the change is slightly increasing CH_4 emissions compared to previous submission (2018) in category 5.A.

In category 5.B Composting, a slowing increase inactivity data trend from 2013 to 2018is reflected by applying less rapidly increasing activity data driver for the 2020 submission resulting in slight decrease in CH_4 emissions projections. In category 5.D Waste water treatment, IEF for CH_4 and N_2O were applied to Eurostat (2020) population estimates, instead of single waste water treatment CO_2 eq. IEF for both emissions. CH_4 decreased and N_2O increased, but the total CO_2 eq. decreased slightly as a result. The total GHG emissions trend stayed stagnant.

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