Reporting on policies and measures and on projections of anthropogenic greenhouse gas emissions by sources and removals of the Czech Republic

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Title: Reporting on policies and measures and on projections of anthropogenic greenhouse gas emissions by sources and removals of the Czech Republic

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EXECUTIVE SUMMARY

The Czech Republic is a Party to the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol. Under these international agreements it is committed to provide annually information on its national anthropogenic greenhouse gas emissions by sources and removals by sinks for all greenhouse gases 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 525/2013 of the European Parliament and of the Council on a mechanism for monitoring and reporting greenhouse gas emissions.

The Czech Republic also every two year fulfils obligations to Regulation (EU) No 525/2013 by 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 comprise 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 documents of the EU. The reference year for both scenarios is the latest year for which emission estimates are available. In this case, the latest reporting year is 2016. The projection years are 2017, 2020, 2025, 2030, 2035 and 2040.

1 Policies and Measures

1 Policies and Measures

1.1 Cross-cutting Policies and Measures

Following chapter describes 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 and 5. Waste).

1.1.1 Emission limits Air Protection Act (201/2012 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 IED Directive is applied from 2016.

The IED Directive sets stricter emission limits for selected basic pollutants (in comparison to repealing Directives) and requires the use of the best available technologies (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 the Best Available Techniques (BAT). BAT conclusions (documents containing information on the emission levels associated with the best available techniques) 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 No. 69/2013 Coll. amending the Act No. 76/2002 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 Czech Hydrometeorological Institute and the company Brucek, Ltd. and 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 (e.g. installation of new boilers) some less efficient and outdated facilities but also to switch to cleaner fuels like natural gas or biomass.

1.1.2 EU ETS

GHG affected: CO_2

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 2003/87/EC amended or supplemented by Directives 2008/101/EC and 2009/29/EC, by Decision No. 1359/13/EU and by Regulation No. 421/2014/EU.

This legislation is transposed into the Czech legislation by Act No. 383/2012 Coll. on conditions for trading of emission allowances amending Acts No. 695/2004 Coll. and No. 164/2010 Coll.

Time framework: There have been agreed three 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) was revised in early 2018 to enable it to achieve 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 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 greenhouse gas emission performance of the 10% best performing installations in the EU ETS.

The benchmarks have been established for various products. This means the benchmark methodology does not differentiate according to the technology, fuel used, or according to 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).The 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. The following table shows drop of GHG emissions caused by energy savings and changes in use of individual energy carriers. Tab. 1-2 shows annual emissions savings from realized and planned investments in for free transitional allocations from the year 2015.

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

Emissions reduction [kt CO_2]	**2015**	**2016**	**2020**	**2025**	**2030**	**2035**
Households	98	74	319	535	892	1194
Services	99	76	292	447	656	877
Industry	188	135	419	568	842	1127
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**	**2016**	**2017**	**2018**	**2019**
	90.095	177.583	1 442.445	163.286	2 360.444

The following table summarizes total effect of EU ETS.

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

Total emissions reduction [kt CO_2]	**2015**	**2016**	**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 Directive 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 to cleaner fuels like natural gas or biomass.

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 or applies 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 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 a 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 will 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.

1.1.4 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 greenhouse gas 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 Policy update, which is planned for 2023.

The Government (see Government Resolution No. 207/2017) adopted the Climate Protection Policy of the Czech Republic in March 2017 and replaced former National Programme to Abate the Climate Change Impacts in the Czech Republic. This Policy reflects significant recent developments at the European Union, 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 greenhouse gas 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 development and voluntary tools.

Mitigation impact:

Primary emission reduction targets

- Greenhouse gas reduction of 32 Mt CO_2 eq. compared to 2005 until 2020
- Greenhouse gas 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 greenhouse gases in 2040
- Indicative level towards 39 Mt CO_2 eq.of emitted greenhouse gases 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 Emission Trading System (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 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.

1.2.1.1 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 is a method for the design and development of a product, which also emphasizes a minimum negative impact of a product on the environment (including energy consumption). A set of requirements are imposed on products which must be met before products enter the market and which also ensures 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 energy-using products.

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. Products categories included in the regulations 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 2014a) of the amount of 1230 TJ/year by 2020.

1.2.1.2 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.

1.2.1.3 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;
- Every year, governments in EU countries must carry out energy efficient renovations on at least 3% (by floor area) of the buildings they own and occupy;
- Consumers should be empowered to manage better energy consumption. This includes easy and free access to data on consumption through individual metering;
- National incentives for SMEs to undergo energy audits;
- Large companies will make audits of their energy consumption to help them 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]
2017	38.93
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.

1.2.1.4 State programme on the promotion of energy savings and the use of renewable energy sources (EFEKT)

GHG affected: CO_2

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

Implementing entity: Ministry of Industry and Trade (Government)

Period of implementation: 2004 – 2016, since 2007 ongoing as the EFEKT Programme

Implemented in scenario: WEM

Categories: 1.A. Fuel combustion

Characteristics of PaM: EFEKT is a national level plan, supporting energy information distribution, enlightenment, organization of public seminars, energy information centers and small investment actions leading to energy savings and use of RES. The sectors covered are the state administration, local (municipalities) and regional governments, schools, social and health care facilities, private sector (undertakings), households and NGO's.

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

Tab. 1-6 Expected energy savings of programme EFEKT

Energy savings [TJ]	2015	2020	2025	2030	2035	2040
	0	298	298	298	298	298

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. 1-7 Expected emissions reduction of programme EFEKT

Emissions reduction [kt CO_2 eq.]	2015	2020	2025	2030	2035	2040
	0.00	21.81	20.10	19.29	17.72	15.07

Only new effects after 2015 are included in the tables.

Additional information: The energy savings in 2020 are expected to be 298 TJ. The budget of the program is estimated to be 0.1 bill. CZK (MIT 2017).

The programme undergoes annual evaluation in order to update contents and budgets of the individual parts of the programme.

The implementation and financing of the State Program complies 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. Since 2007, the Program is called Program EFEKT and is implemented only by the Ministry of Industry and Trade.

1.2.1.5 State programme on the 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: measures to reduce the energy intensity of public street lighting; reconstruction of a heating system and the heat generation in a building; publications, guides and informative materials about the energy sector; introduction of an energy management system; preparation of energy-saving projects financed using the EPC method.

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

Tab. 1-8 Expected energy savings of programme EFEKT 2

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

Using emission factors, which recpect 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 of programme EFEKT 2

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

Additional information: The budget of the program is estimated to be 0.7 bill. CZK 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.

1.2.1.6 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 once:

- 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 shows the following table.

Tab. 1-10 Expected energy savings of the programme Operational Programme Enterprise and Innovation for Competitiveness

Energy savings [TJ]	2015	2020	2025	2030	2035	2040
	0	10 640	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. 1-11 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
	0.00	799.37	1160.04	1122.63	1045.09	893.72

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. 1-12 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
Electricity generation from RES [TJ]	0.0	427.4	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
GHG emissions reduction [kt CO_2 eq.]	0.0	99.4	280.2	258.0	216.2	163.9

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

1.2.1.7 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 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 another PaMs (e.g.: New Green savings programme, Operational Programme Environment, Integrated Regional Operating Programme, Program JESSICA, etc.).

1.2.1.8 JESSICA Programme

GHG affected: CO_2

Type of policy: Economic

Implementing entity: Ministry of Regional Development (Government)

Period of implementation: 2014 – 2016

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 programme offers long-term low-interest loans for reconstruction or modernization of residential buildings. The programme is designed for all owners of residential houses:

- Municipalities
- Housing Cooperatives
- Other legal and natural persons owning residential building
- Community of apartment owners
- Non-profit organizations for social housing.

The program focuses on:

- Insulation of internal structures and external cladding including replacement of windows and doors,
- Reconstruction of technical equipment (e.g. heating system, plumbing, heating, gas, water, air conditioning, elevators),
- Replacement or modernization of loggias, balconies, railings,
- Repairing static failures of supporting structures,

- Rehabilitation of foundations and waterproofing of substructures,
- Provision of modern social housing through renovation of existing buildings.

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

Tab. 1-13 Expected energy savings of the JESSICA programme

Energy savings [TJ]	2015	2020	2025	2030	2035	2040
	0	24	24	24	24	24

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. 1-14 Expected emissions reduction related to energy savings of the JESSICA programme

Emissions reduction [kt CO_2 eq.]	2015	2020	2025	2030	2035	2040
	0.00	2.05	1.91	1.85	1.74	1.59

Additional information: The expected annual budget for the period 2014 – 2020 is estimated to be about 0.6 bill. CZK (23.1 mill. €) (MIT 2017).

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: The period of implementation was not specified at the time of document preparing.

Implemented in scenario: WAM

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 shows the following table.

Tab. 1-15 Expected energy savings of the Energ Programme

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

Using emission factors, which recpect 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. 1-16 Expected emissions reduction related to energy savings of the Energ programme

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

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 shows the following table.

Tab. 1-17 Expected energy savings of the Operational Programme Prague Growth Pole

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

Using emission factors, which recpect 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. 1-18 Expected emissions reduction related to energy savings of the Operational Programme Prague Growth Pole

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

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 Operational Programme Enterprise and Innovation (OPEI): Eco-Energy

GHG affected: CO_2, CH_4, N_2O

Type of policy: Economic (subsidies)

Implementing entity: Ministry of Industry and Trade (Government)

Period of implementation: 2007 – 2013

Implemented in scenario: WEM

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

Characteristics of PaM: The Priority axis 3 (Eco-Energy) of the OPEI supported by The Ministry of Industry and Trade (MIT) had seven priority axes (e.g. Development of firms, Innovation, Business development services, Technical assistance). The priority axis 3 (Effective Energy or Eco-Energy) was focused on energy savings and on the use of RES (renewable energy sources) and thus aiming at GHG reduction.

The program aimed at reducing energy intensity in production processes, at reducing fossil fuel consumption and at a higher usage of renewable and secondary energy sources. The aid beneficiaries were not only small- or medium-sized, but also large enterprises.

The support focused also on building of new facilities for generation and transmission of electricity and thermal energy generated from RES and on the reconstruction of existing production facilities in order to use renewable energy sources. Further support was provided for modernization of existing energy production facilities to increase their efficiency and for implementation of systems for measurement and regulation of energy. Further, modernization and loss reduction in the transmission of electricity and heat and to the use of waste energy in industrial processes were encouraged.

Funding was derived in part from European Regional Development Fund (ERDF) (85%) and partly from the state budget (15%). The support was provided in the form of subsidies or subsidized loans for all projects on the territory of the Czech Republic except the capital city of Prague. Half of the funds allocated to this priority were designated for energy savings and another half for the use of RES.

The aim of the program was to use the grants in order to stimulate enterprises in reducing the production energy requirements and the consumption of primary energy sources, and to promote a higher utilization of renewable and secondary energy sources.

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

Tab. 1-19 Energy savings of the OPEI programme

	2015	2020	2025	2030	2035	2040
Energy savings [TJ]	0	1 105	1 105	1 105	1 105	1 105

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. 1-20 Emissions reduction resulting from energy savings of the OPEI programme

	2015	2020	2025	2030	2035	2040
Emissions reduction [kt CO_2 eq.]	0.00	107.10	98.41	95.24	88.66	75.82

Besides energy savings, the programme supported use of RES as well. The calculation of emissions savings uses amounts of electricity and heat produced from RES, again with respect to development of fuel mix used for electricity and heat production.

Tab. 1-21 Energy production from RES and corresponding emissions reduction of the OPEI programme

	2015	2020	2025	2030	2035	2040
Electricity generation from RES [TJ]	0.0	451.8	451.8	451.8	451.8	451.8
Heat generation from RES [TJ]	0.0	58.5	58.5	58.5	58.5	58.5
GHG emissions reduction [kt CO_2 eq.]	0.0	86.8	86.8	86.8	86.8	86.8

All three tables account only to new emissions savings after the year 2015, because emissions savings in the year 2015 are already included in the emission inventories.

Additional information: According to the latest programme annual report, the eligible costs of realized projects were 777.8 mill. €. The corresponding subsidies from the EU and national funds were 303.3 mill. €.

1.2.2 Policies and measures in 1.A.1

1.2.2.1 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.

1.2.2.2 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

Implemented in scenario: WEM

Sectors: 1.A.1. Energy industries

Characteristics of PaM: The plan implements Renewable Energy 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

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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.

- 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 NREAP (MIT 2015) currently proposes for 2020 a higher share of RES in final energy consumption (15.3%) in comparison to the target of Directive 2009/28/EC (13%; see Tab. 1-22 and Tab. 1-23). The main renewable energy sources in the CR 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. 1-22 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. 1-23 Share of RES on final consumption of energy according to NREAP, 2015 (MIT 2016)

	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.

1.2.2.3 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 CR.

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.

Not only electricity from biomass, but also photovoltaic-, wind- and hydropower plants are financially supported. In 2016 the installed capacity of photovoltaic and wind power plants reached 2127 MW and 285 MW respectively.

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.

For the estimation of effects of the preferential feed-in tariffs, about 50% of newly built power plants using RES are attributed to this measure.

Since 2014 power plants using RES (except small hydro power plants up to capacity of 10 MWe) are not supported anymore. Only power plants with a permit for installation until the end of the year 2013 were supported. 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 15.2 % 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. 1-24 Emissions reduction expected from introduction of preferential feed-in tariffs for electricity produced from RES

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

1.2.3 Policies and measures in 1.A.3

1.2.3.1 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 CO2 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 435.79 kt. CO_2 eq. in 2035 year.

Additional information: The 2017 target is 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.

1.2.3.2 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 CO2 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 3663 kt CO2 eq. in 2035 year. Such a big reduction is calculated due to big difference between target 95 g/km of CO2 and present CO2 implied emission factors (derived from COPERT), which are in the range between 160-230 g/km for passenger cars, depending on a car category.

1.2.3.3 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 198 kt CO_2 eq. in 2035 year.

1.2.3.4 Support of public transport and modal shift from road transport

GHG affected: CO_2

Type of policy: Regulatory

Implementing entity: Totally fourteen regional authorities (the Czech Republic has fourteen regions including the capital of Prague, all these regions make effort to develop integrated transport systems (IDS), in some regions (Southern and Northern Moravian, Olomouc, Middle Bohemian) these systems already exists, in other regions are prepared**)**

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

Implemented in scenario: WEM

Characteristics of PaM:

Increasing the attractiveness of public transport:

a) Introduction of the integrated transport system (IDS)

The integrated transportation 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 the 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 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 171.7 kt. CO2 eq. in 2035 year.

1.2.3.5 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 2015a).

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.

1.2.3.6 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.

1.2.3.7 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.

1.2.3.8 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: charging the use of the transport infrastructure for freight vehicles (Road Traffic Law 13/1997 and its amendments), a road tax reduction for the "purer" 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.

1.2.3.9 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 are charged now in the Czech Republic. The road charging will involve selected first and second class roads as well.

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., 2014). The total emission reduction of this measure is 161.9 kt. CO2 eq. in 2035 year.

1.2.4 Policies and measures in 1.A.4

1.2.4.1 Operational Program Environment 2007 – 2013

GHG affected: CO_2

Type of policy: Economic

Implementing entity: State Environmental Fund (Government)

Period of implementation: 2007 - 2013

Implemented in scenario: WEM

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

Characteristics of PaM: The Operational Programme Environment was focused on improving the quality of the environment. It helped to improve air, water and soil quality. It also addressed waste and industrial pollution. The program promoted landscape care, the use of renewable sources and the building of environmental infrastructure.

This program was primarily focused on the public sector (e.g. municipalities, regions, organizations partly funded from the public purse, state enterprises, non-governmental non-profit organizations). However, in certain areas also business entities and natural persons were included.

The Operational Programme Environment had eight priority axes. In terms of energy savings, the priority axis 3 was the most significant. This priority axis supported projects for the construction or reconstruction of facilities using renewable energy sources and cogeneration and projects aimed at energy savings and the reuse of waste heat in the non-business sector. Priority axis 2 was also significant. It focused on improving air quality, which also resulted in reduction of energy consumption.

Mitigation impact: The final programme report declares the following energy savings.

Tab. 1-25 Energy savings of Operational Program Environment 2007 – 2013

Energy savings [TJ]	2015	2020	2025	2030	2035	2040
	0	824	824	824	824	824

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. 1-26 Emissions reduction related to energy savings of Operational Program Environment 2007 – 2013

Emissions reduction [kt CO_2 eq.]	2015	2020	2025	2030	2035	2040
	0.00	92.77	81.25	74.07	65.50	53.32

Besides energy savings, the programme supported use of RES as well. The calculation of emissions savings uses amounts of electricity and heat produced from RES, again with respect to development of fuel mix used for electricity and heat production. The following table shows electricity and heat production from RES as indicated in the final programme report ant the derived emission drops.

Tab. 1-27 Energy production from RES and reached emissions reduction of Operational Program Environment 2007 – 2013

	2015	2020	2025	2030	2035	2040
Electricity generation from RES [TJ]	0.0	2.3	2.3	2.3	2.3	2.3
Heat generation from RES [TJ]	0.0	242.3	242.3	242.3	242.3	242.3
GHG emissions reduction [kt CO_2 eq.]	0.0	26.9	23.8	22.2	20.4	17.9

All three tables account only to new emissions savings after the year 2015, because emissions savings in the year 2015 are already included in the emission inventories.

Additional information: According to the final programme report, the total certified costs reported to the EC of realized projects were 1,069 mill. €.

1.2.4.2 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. 1-28 Energy savings of Operational Program Environment 2014 – 2020

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

Notice: The s table contains not only emissions drop resulting from higher efficiency of new boilers but also drop from switching from fossil fuels to RES, because RES were calculated as energy savings.

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. 1-29 Emissions reduction related to energy savings of Operational Program Environment 2014 – 2020

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

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. 1-30 Energy production from RES and reached emissions reduction of Operational Program Environment 2014 – 2020

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

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

1.2.4.3 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 (NEW PANEL since 2009, 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. 1-31 Expected energy savings of the PANEL programme

	2015	2020	2025	2030	2035	2040
Energy savings [TJ]	0	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. 1-32 Expected emissions reduction related to energy savings of the PANEL programme

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

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

1.2.4.4 New Green Savings Programme 2013

GHG affected: CO_2

Type of policy: Economic

Implementing entity: State Environmental Fund (Government)

Period of implementation: 2013

Implemented in scenario: WEM

Category: 1.A.4.b. Residential

Characteristics of PaM: The New Green Savings Programme 2013 was a subsidy program of the Ministry of Environment (administrated by the State Environmental Fund) focused on energy savings and the use of renewable energy in single-family buildings.

The program exclusively focused on the insulation of family houses in combination with the replacement of inefficient boilers using solid fuels. The program further supported the installation of solar systems for hot water.

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

Tab. 1-33 Expected energy savings of the New Green Savings Programme 2013

Energy savings [TJ]	2015	2020	2025	2030	2035	2040
	0	103	103	103	103	103

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 New Green Savings Programme 2013

Emissions reduction [kt CO_2 eq.]	2015	2020	2025	2030	2035	2040
	0.00	5.01	4.35	4.05	3.76	3.42

Additional information: The expected annual budget for the period 2014 – 2020 is estimated to be about 0.6 bill. CZK (23.1 mill. €) (MIT 2017).

1.2.4.5 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 and is successor of the previous two same-named programmes. 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. biomass; installation of heat pumps and 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. 1-35 Expected energy savings of the New Green Savings Programme 2014 – 2020

Energy savings [TJ]	2015	2020	2025	2030	2035	2040
	0	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. 1-36 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
	0.00	529.50	467.67	437.83	404.26	364.01

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

1.2.4.6 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. 1-37 Expected energy savings of the Integrated Regional Operating Programme

	2015	2020	2025	2030	2035	2040
Energy savings [TJ]	0	2,561	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. 1-38 Expected emissions reduction related to energy savings of the Integrated Regional Operating Programme

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

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

1.2.4.7 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.

1.3 Policies and Measures in Industrial Processes and Product Use sector

Policies and Measures under 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 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.

1.3.2 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.

1.3.3 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 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.

1.4.2 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 are available on: http://eagri.cz/public/web/mze/. 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.

1.4.3 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 Europe 2020 strategy, those general objectives of rural development support in the period 2014–2020 are more specifically expressed in the following six priorities applicable to the whole of the EU. Each measure from the offer of the rural development regulation may contribute to the objectives of several priorities.

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 that GHG emissions reduction for year 2020 will be approximately 200 kt CO_2 eq. and 357 kt CO_2 eq. for year 2035.

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.

1.4.4 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.

1.4.5 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.

1.4.6 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.

1.4.7 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 unprecedented 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 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.

1.5.2 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; ME 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.

1.6 Policies and Measures in Waste sector

Greenhouse gas emissions generated by the waste sector in the Czech Republic have been growing due to organic carbon that is accumulated in landfills, increasing amount of produced MSW (municipal solid waste) 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 slowing we observe is mainly due to increased LFG (landfill gas) capturing.

There is a potential for emission reductions in fulfilling the EU obligations of the Circular Economy Package (CEP) (COM/2015/0614) and other national measures with emission reduction effects which are related to common waste policy in the country. Waste incineration measures will also affect industrial waste generated by other industries. Policies and measures 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 (COM/2015/0614). The assumption is that the new obligations and recycling targets of the CEP will be met. See chapter 1.6.1 for more details about the new targets. Member states have 24 months to implement the CEP into national law (EC 2018).

There are several policies that are not part of waste legislation that already have or will have impact on GHG emissions from waste. Most of them are mentioned in the cross sectoral section in this report but above all is worthy to mention EU ETS, Climate & Energy Package and Energy Tax Directive which provide direct and indirect support on LFG recovery and therefore significantly influencing landfill emissions.

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 for the expansion of the facility network and is financed from EU Cohesion Fund (MoE 2014).

1.6.1 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 (COM/2015/0614) 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: Member states have 24 months to implement the CEP into national law.

1.6.2 Waste Management Plan 2003 and 2011

GHG affected: CH_4

Type of policy: Economic, Fiscal

Implementing entity: Ministry of Environment (Government)

Period of implementation: 2003 - 2014

Implemented in scenario: WEM

Characteristics of PAM: The most important instrument on the national level focused on reducing CH4 emissions from waste was the Waste management plan (WMP) (MoE 2003). It was valid until 2011 and then the WMP (MoE 2003) had been reworked with certain shifts in waste management practice, e.g. more focus on energy recovery. Most of targets and measures were in compliance with obligatory EU legislation. There were several programs aimed at reaching goals of WMP (MoE 2003). The main one was the Operational Programme Environment, priority axis 4: Waste Management and the Rehabilitation of Existing Ecological Burdens. This axis had budget EUR over 776 million from the EU Cohesion Fund. For more detailed financial information on the funded projects that had relevance to GHG emissions reduction, see Additional information.

Mitigation impact: During 2009 - 2014 the waste management options developed as follows: municipal waste recovery rose 85%, energy recovery rose 96%, composting rose 125% and landfilling decreased 30%. The time period begins from 2009 because the official database VISOH, which is run by the Ministry of Environment, shows values from 2009. Over the period of 2005 - 2014 GHG emissions rose by 1.11 Mt CO_2 eq. or 26%.

Additional information: The increasing share of recovered waste to the waste disposed is due to three main points. 1. Change for more efficient technology in manufacturing sector, 2. Waste is perceived as a source of raw material, 3. Financial support of 776 million euros from OPE 2007 - 2013 has actualized impacts from WMP (MoE 2014). From OPE’s 520.3 million euros, 192 million was allocated for separate collection, 92 million for collection yards, 92 million for composting, 96 million for other waste management projects and 44 million for combination of above projects. Total number of supported projects was 3963. A currency converter of 25 was applied.

1.6.3 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 Waste management plan of the Czech Republic, is based on the principle of respect for the waste management hierarchy which is:

1. Waste prevention
2. Preparing for re-use
3. Waste recycling
4. Other recovery, e.g. energy
5. Waste disposal

WMP 2014 (MoE 2014) was drawn up by considering other policies and measures related to GHG emissions from waste management:

- State Environmental Policy of the Czech Republic 2012-2020, which defines the plan for the implementation of effective environmental protection in the Czech Republic until the year 2020. This policy was updated in 2016.
- Raw Material Policy of the Czech Republic 2012-2032.This document reflects the economic developments in Europe and in the world and the changes in global raw materials market. The document aims to ensure the raw material security of the state.
- Secondary raw materials policy of the Czech Republic – the basic vision of this document is "turning waste into resource." The document was created in order to create favourable conditions for the recovery of "secondary raw materials" from products and materials, which have completed their life cycle, and for their processing and recovery. The main objective is the replacement of primary natural resources by "secondary raw materials" and to contribute in this way to reducing material and energy intensity of production.
- Biomass Action Plan of the Czech Republic 2012-2020. The plan presents an analysis of the use of biomass in the Czech Republic for energy purposes and proposes appropriate measures for the sustainability of the connection between agriculture and energy sector until 2020.
- State Energy Policy of the Czech Republic. This is a strategic document defining the objectives of the state in energy management in accordance with the needs for economic and social development, including environmental protection, serving also for the development of territorial energy concepts.

The new 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 2015 - 2016 the waste management options developed as follows: material recovery rose 14%, composting rose 12%, energy recovery rose 10%, and landfilling decreased 1%. The projected impact for the 2015 - 2024 waste management options is respectively 28%, 119%, 87% and -67%. The assumption for GHG emission reduction is 0.56 Mt CO_2 eq or 10% over the period of 2015 – 2024, but compared to 2005 - 2024, emissions will have increased by 0.65 Mt CO_2 or 15%. Over the period of 2005 - 2016 GHG emissions rose by 1.27 Mt CO_2 eq. or 29%.

Additional information: The OPE 2014 – 2020 is a direct continuation of OPE 2007-2013 and is also financed from the Cohesion Fund. The priorities of project support in waste management are determined by the obligations of the Circular Economy Package (COM/2015/0614), the WMP (MoE 2014) and also by the Programme of waste prevention of the Czech Republic (MoE 2014a). From 468 million euros, 19.2 million is allocated for preventing municipal waste generation, 44 million for preventing industrial waste generation, 68 million for construction and modernization of waste collection, sorting and treatment facilities, 104 million for material recovery of waste, 52 million for energy recovery of waste and 22.8 million for construction and modernization of hazardous waste management facilities. A currency converter of 25 was applied.

2 Projected greenhouse gas emissions by gas and source

2 Projected greenhouse gas emissions by gas and source

Projections of greenhouse gas 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 process of greenhouse gas emission projections includes the following set of steps:

(i) Selection of the latest available National Inventory Report – The latest National Inventory Report available during the preparation of projections was published in year 2018 (CHMI 2018). National Inventory Report (NIR) (CHMI 2018) contains emission estimates for sectors mentioned above for time series 1990 - 2016. According to the NIR, total greenhouse gas emissions including indirect emissions and LULUCF were 125.01 Mt CO_2 eq. in 2016. Emissions decreased by 35% compared to 1990. Total emissions including indirect emissions and excluding LULUCF were 130.35 Mt CO_2 eq. Emissions decreased by 35% compared to 1990. The trend of total greenhouse gas emissions of the Czech Republic for 1990 – 2016 is depicted on Fig. 2-1.

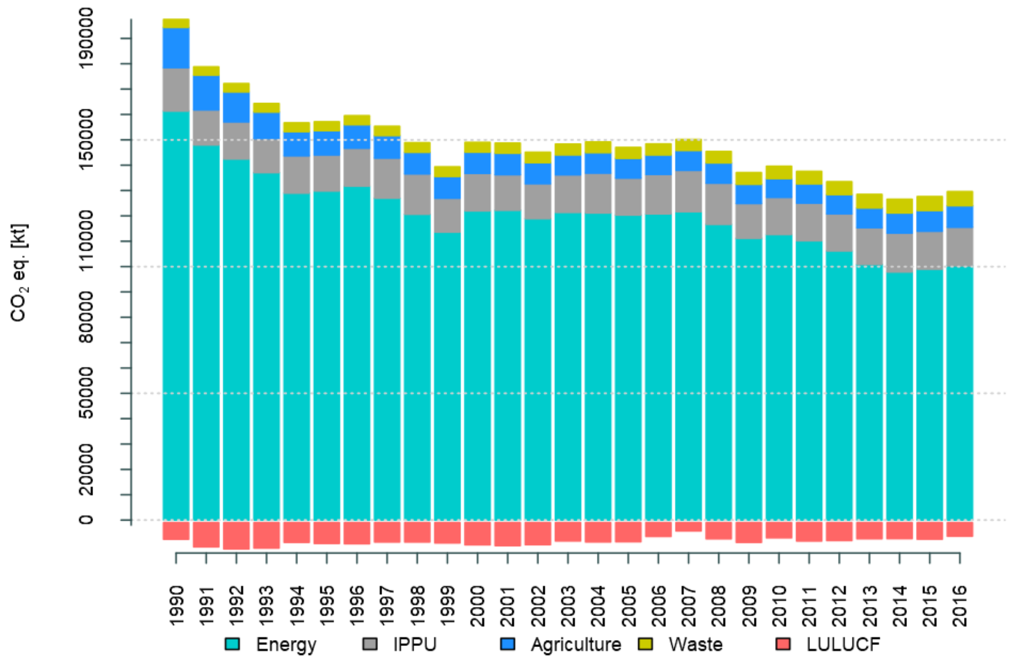

Fig. 2-1 Total greenhouse gas emissions of the Czech Republic for 1990 – 2016 (CHMI 2018)

The results of greenhouse gas inventory published in National Inventory Report (CHMI 2018) (including LULUCF) are shown in Tab. 2-1. The highest share on total greenhouse gas emissions (81%) in 2016 has sector Energy; 96% of these emissions arise from fuel combustion activities. The share of other sectors on total greenhouse gas emissions is following: IPPU 12%, Agriculture 7% and Waste 5%. LULUCF is the only sector where removals exceed emissions.

Tab. 2-1 Overview of GHG emission/removal trends by CRF categories (CHMI 2018)

	Base year kt CO_2 eq.	2016 kt CO_2 eq.	2016 Total share [%]	2016 Sectoral share [%]	Trend %
1. Energy	**161339.98**	**100280.60**	**80.71**	**100.00**	**-37.85**
A. Fuel combustion (sectoral approach)	149478.48	96249.72	77.47	95.98	-35.61
1. Energy industries	56915.91	54449.09	43.82	54.30	-4.33
2. Manufacturing industries and construction	51234.04	9396.92	7.56	9.37	-81.66
3. Transport	7284.03	18449.82	14.85	18.40	153.29
4. Other sectors	34044.50	13546.23	10.90	13.51	-60.21
5. Other	NO	407.66	0.33	0.41	100.00
B. Fugitive emissions from fuels	11861.51	4030.88	3.24	4.02	-66.02
1. Solid fuels	10779.39	3420.64	2.75	3.41	-68.27
2. Oil and natural gas and other emissions from energy production	1082.12	610.25	0.49	0.61	-43.61
C. CO_2 transport and storage	NO	NO	NA	NA	0.00
2. Industrial Processes	**17113.01**	**15221.74**	**12.25**	**100.00**	**-11.05**
A. Mineral industry	4082.45	2816.07	2.27	16.44	-31.02
B. Chemical industry	2944.23	1527.23	1.23	13.44	-48.13
C. Metal industry	9670.32	7311.48	5.88	44.74	-24.39
D. Non-energy products from fuels and solvent use	125.56	139.73	0.11	0.91	11.28
E. Electronic industry	NO,NE	6.39	0.01	0.12	100.00
F. Product uses as ODS substitutes	NO	3122.53	2.51	22.43	100.00
G. Other product manufacture and use	290.46	298.31	0.24	1.93	2.70
H. Other	NO	NO	NA	NA	0.00
3. Agriculture	**15898.12**	**8519.68**	**6.86**	**100.00**	**-46.41**
A. Enteric fermentation	5754.89	2957.46	2.38	34.14	-48.61
B. Manure management	3315.36	1580.18	1.27	20.97	-52.34
C. Rice cultivation	NO	NO	NA	NO	0.00
D. Agricultural soils	5531.71	3603.26	2.90	40.76	-34.86
E. Prescribed burning of savannas	NO	NO	NA	NO	0.00
F. Field burning of agricultural residues	NO	NO	NA	NO	0.00
G. Liming	1187.63	168.01	0.14	1.92	-85.85
H. Urea application	108.53	210.76	0.17	2.21	94.19
I. Other carbon-containing fertilizers	NO	NO	NA	NA	0.00
J. Other	NO	NO	NA	NA	0.00
4. Land use, land-use change and forestry	**-6562.80**	**-5337.14**	**-4.30**	**100.00**	**-18.68**
A. Forest land	-5076.02	-4519.32	-3.64	91.15	-10.97
B. Cropland	213.22	124.36	0.10	-0.07	-41.67
C. Grassland	-96.83	-661.65	-0.53	8.29	583.32
D. Wetlands	21.48	25.03	0.02	-0.38	16.52
E. Settlements	86.31	124.06	0.10	-1.33	43.73
F. Other land	NO,NA	NO,NA	NA	NA	0.00
G. Harvested wood products	-1712.97	-430.67	-0.35	2.47	-74.86
H. Other	NO	NO	NA	NA	0.00
5. Waste	**3124.51**	**5561.26**	**4.48**	**100.00**	**77.99**
A. Solid waste disposal	1979.27	3671.11	2.95	64.40	85.48
B. Biological treatment of solid waste	NE,IE	711.36	0.57	12.91	100.00
C. Incineration and open burning of waste	21.25	115.99	0.09	2.57	445.73
D. Waste water treatment and discharge	1123.99	1062.80	0.86	20.12	-5.44
E. Other	**NO**	**NO**	**NA**	**NA**	**NA**
Total CO_2 equivalent emissions without land use, land-use change and forestry	**197475.63**	**129583.28**	**-**	**-**	**-34.38**
Total CO_2 equivalent emissions with land use, land-use change and forestry	**190912.83**	**124246.14**	**100.00**		**-34.92**
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry	**199597.37**	**130348.69**	**-**	**-**	**-34.69**
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry	**193034.57**	**125011.55**	**-**	**-**	**-35.24**

(ii) Selection of base year, final year and cross-cutting years for projections – The year 2016 was selected as a base year for projections of greenhouse gas emissions. Year 2016 is the latest year with available information on macroeconomic development, energy balances and emission estimates. The year 2040 was selected as a final year, in accordance with the recommendations of the EU. The years 2020, 2025, 2030, 2035 and 2040 were selected as a cross-cutting years.

(iii) Selection of the actual methodology and model instruments for preparing the projection – More detailed information about methodology and model instruments used for projections of greenhouse gas emissions 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 projections of greenhouse gas emissions can be found in chapter Methodological issues for each sector.

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

(vi) Definition of scenarios – Greenhouse gas emission projections contain two scenarios: with existing measures (WEM) and with additional measures (WAM). Policies and measures introduced before 1st July 2018 are considered as existing measures and thus those measures are reflected in WEM scenario. Policies and measures introduced after 1st July 2018 are considered as additional measures and thus those measures are reflected in WAM scenario. More detailed information about policies and measures and their implementation can be found in chapter 1 Policies and Measures.

(vii) Calculation of scenarios and presentation of their results – Results of greenhouse gas emission projections are presented for each sector as a total emissions 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 – More detailed information about sensitivity analysis and results of sensitivity analysis can be found in chapter Sensitivity analysis for each sector.

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

According to the current projections (Tab. 2-2 and Fig. 2-2) is expected that total greenhouse gas emissions are going to slightly increase in next few years for both scenarios. Around the year 2025 it is forecasted that emissions will start to decrease and the decrease of emissions will continue to year 2040. Slight difference between WEM and WAM scenario is caused by additional measures in Energy, LULUCF and Waste. The WAM scenario in Energy includes additional measures in Transport (for more details please see chapter 2.2). The WAM scenario in LULUCF includes the proposed change of dominantly spruce even-aged forests stand to more diverse stands with a notably higher share of broadleaved tree species such as beech and oak, applicable to period until 2040 (for more details please see chapter 2.5.). The WAM scenario in Waste involves increased recovery of landfill gas (for more details please see chapter 2.6.). Numerously, it is expected for WEM scenario that total greenhouse gas emissions in 2040 will amount to 91.59 Mt CO_2 eq. which will represent 52% decrease of emissions compared to 1990, 34% decrease of emissions compared to 2005 and 26% decrease of emissions compared to 2016. For WAM scenario it is expected that total greenhouse gas emissions in 2040 will amount to 92.29 Mt CO_2 eq. which will represent 52% decrease of emissions compared to 1990, 34% decrease of emissions compared to 2005 and 26% decrease of emissions compared to 2016.

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

	Reported emissions			Projected emissions					Difference [%]		
[Mt CO_2 eq.]	1990	2005	2016	2020	2025	2030	2035	2040	1990 – 2020	1990 – 2030	1990 – 2040
WEM	190.91	139.45	124.25	126.83	112.85	108.22	97.84	91.59	-33.57	-43.31	-52.02
WAM	190.91	139.45	124.25	127.18	113.12	108.71	97.78	92.29	-33.38	-43.05	-51.66

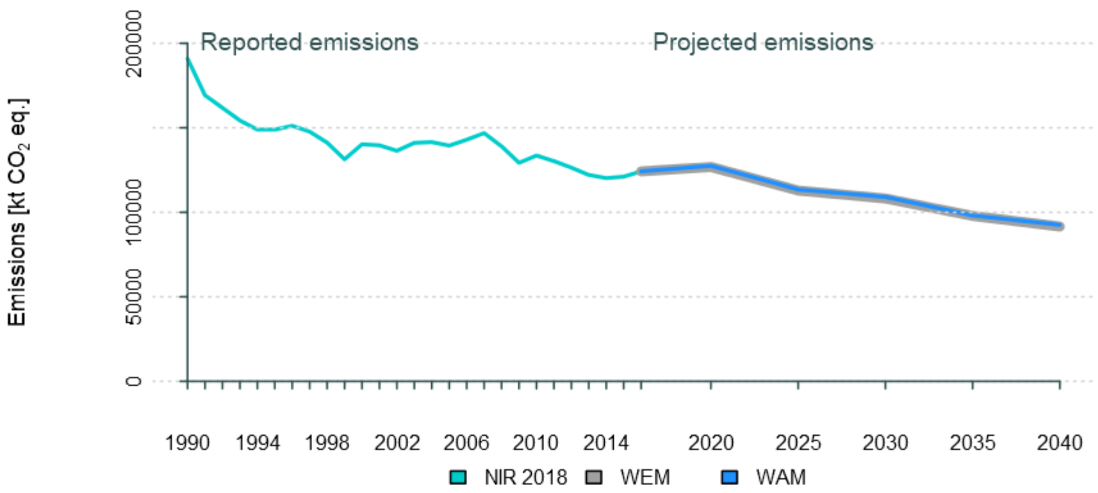

Fig. 2-2 Reported and projected emissions of GHG – WEM, WAM (including LULUCF)

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

According to the WEM scenario it is expected that emissions are going to decrease for all monitored greenhouse gases except of N_2O. Emissions of N_2O are going to increase in 2025 – 2040; increase is caused mainly due to increase of emissions from sector Agriculture (for more details please see chapter 2.4). The highest decrease of emissions compared to 2005 and 2016 level of emissions is expected for F-gases; mainly for HFCs in category 2.F.1 Refrigeration and Air Conditioning. Consumption of F-gases is regulated on EU level but also worldwide and thus it is expected that emissions will start to decrease in coming years (for more details please see chapter 2.3).

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

	Reported emissions			Projected emissions					Difference [%]		
[Mt CO_2 eq.]	1990	2005	2016	2020	2025	2030	2035	2040	1990 – 2020	1990 – 2030	1990 – 2040
CO_2	157.58	117.67	101.15	103.81	90.79	87.93	78.80	73.90	-34.12	-44.20	-53.10
CH_4	23.66	14.68	13.77	13.61	13.09	12.07	11.39	10.23	-42.46	-48.97	-56.77
N_2O	9.59	6.14	6.09	5.89	6.08	6.21	6.24	6.24	-38.54	-35.21	-34.89
HFCs	NO	0.79	3.12	3.44	2.81	1.93	1.35	1.15	NA	NA	NA
PFCs	NO	0.01	0.00	0.00	0.00	0.00	0.00	0.00	NA	NA	NA
SF_6	0.08	0.11	0.08	0.07	0.07	0.06	0.06	0.06	-11.16	-21.61	-27.36
NF_3	NO	NO	0	0.00	0.00	0.00	0.01	0.01	NA	NA	NA
Total	**190.91**	**139.45**	**124.25**	**126.83**	**112.85**	**108.22**	**97.84**	**91.59**	**-33.57**	**-43.31**	**-52.03**

Predicted trend of greenhouse gas emissions for individual sectors is on Tab. 2-4. The most rapid decrease of greenhouse gas emissions is expected for sector Energy. For sector IPPU is expected decrease of F-gas emissions but it is not expected that emissions related to e.g. mineral, chemical, iron and steel production will rapidly decrease, as it is not expected that production capacity of facilities will decrease during next decades. For sector Agriculture is expected that greenhouse gas emissions will increase during projected period; increase of emissions is mainly linked with planned increase of animal population. According to the LULUCF projections is expected that the LULUCF will significantly loose its emission sink strength. For sector Waste is projected decrease of emissions compared to current level of emissions.

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

	Reported emissions			Projected emissions					Difference [%]		
[Mt CO_2 eq.]	1990	2005	2016	2020	2025	2030	2035	2040	1990 – 2020	1990 – 2030	1990 – 2040
1. Energy	161.34	120.35	100.28	96.49	85.66	82.15	73.03	67.59	-40.20	-49.08	-58.11
2. IPPU	17.11	14.55	15.22	16.05	15.35	14.43	13.78	13.60	-6.23	-15.71	-20.52
3. Agriculture	15.90	7.80	8.52	8.36	8.77	9.05	9.15	9.17	-47.41	-43.06	-42.29
4. LULUCF	-6.56	-7.54	-5.34	0.55	-1.74	-1.63	-1.73	-1.81	-108.44	-75.22	-72.41
5. Waste	3.12	4.29	5.56	5.38	4.81	4.22	3.61	3.03	72.20	35.02	-2.92
Total	**190.91**	**139.45**	**124.25**	**126.83**	**112.85**	**108.22**	**97.84**	**91.59**	**-33.57**	**-43.31**	**-52.03**

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

The difference between WEM and WAM scenario is not so significant. WAM scenario includes additional measures in Energy (Transport), LULUCF and Waste. It is expected that total greenhouse gas emissions in 2040 will be according to WAM scenario slightly higher than according to the WEM scenario. This unusual difference is caused by additional measure in LULUCF which it should warrant additional important benefits (for more details please see chapter 2.5).

From the side of individual gases, the trend of projected greenhouse gas emissions is very similar to the trend of emissions according to WEM scenario.

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

	Reported emissions			Projected emissions					Difference [%]		
[Mt CO_2 eq.]	1990	2005	2016	2020	2025	2030	2035	2040	1990 – 2020	1990 – 2030	1990 – 2040
CO_2	157.58	117.67	101.15	104.17	91.08	88.70	79.58	75.32	-33.90	-43.71	-52.20
CH_4	23.66	14.68	13.77	13.61	13.08	11.80	10.55	9.51	-42.46	-50.11	-59.79
N_2O	9.59	6.14	6.09	5.89	6.07	6.21	6.23	6.24	-38.59	-35.28	-34.94
HFCs	NO	0.79	3.12	3.44	2.81	1.93	1.35	1.15	NA	NA	NA
PFCs	NO	0.01	0	0.00	0.00	0.00	0.00	0.00	NA	NA	NA
SF6	0.08	0.11	0.08	0.07	0.07	0.06	0.06	0.06	-11.16	-21.61	-27.36
NF3	NO	NO	0	0.00	0.00	0.00	0.01	0.01	NA	NA	NA
Total	**190.91**	**139.45**	**124.25**	**127.18**	**113.12**	**108.71**	**97.78**	**92.29**	**-33.38**	**-43.05**	**-51.66**

Predicted trend of greenhouse gas emissions for individual sectors is on Tab. 2-6. The trend of the greenhouse gas emissions is very similar to trend of emissions for WEM scenario. According to the WAM scenario it is expected that emissions from Energy and Waste should be lower than predicted emissions according to WEM scenario. The loose of emission sink strength of LULUCF is more obvious in WAM scenario.

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

	Reported emissions			Projected emissions					Difference [%]		
[Mt CO_2 eq.]	1990	2005	2016	2020	2025	2030	2035	2040	1990 – 2020	1990 – 2030	1990 – 2040
1. Energy	161.34	120.35	100.28	96.15	85.28	81.78	72.69	67.29	-40.41	-49.31	-58.29
2. IPPU	17.11	14.55	15.22	NE	NE	NE	NE	NE	NA	NA	NA
3. Agriculture	15.90	7.80	8.52	NE	NE	NE	NE	NE	NA	NA	NA
4. LULUCF	-6.56	-7.54	-5.34	1.25	-1.09	-0.49	-0.61	-0.10	-118.97	-92.51	-98.46
5. Waste	3.12	4.29	5.56	5.38	4.80	3.95	2.77	2.32	72.20	26.38	-25.77
Total	**190.91**	**139.45**	**124.25**	**127.18**	**113.12**	**108.71**	**97.78**	**92.29**	**-33.38**	**-43.06**	**-51.66**

2.1.3 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

	Reported emissions		Projected emissions					Difference [%]		
[Mt CO_2 eq.]	2005	2016	2020	2025	2030	2035	2040	2005 – 2020	2005 – 2030	2005 – 2040
EU ETS	82.50	65.54	63.07	56.24	55.87	49.86	47.66	-23.56	-32.28	-42.23
ESD	64.50	64.04	63.20	58.34	53.96	49.70	45.72	-2.02	-16.34	-29.11

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

	Reported emissions		Projected emissions					Difference [%]		
[Mt CO_2 eq.]	2005	2016	2020	2025	2030	2035	2040	2005 – 2020	2005 – 2030	2005 – 2040
EU ETS	82.50	65.54	63.07	56.24	55.87	49.86	47.66	-23.56	-32.28	-42.23
ESD	64.50	64.04	62.86	57.95	53.32	48.52	44.72	-2.55	-17.33	-30.67

2.2 Energy

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

CO_2 emissions from the category 1.A decreased by 36% from 147 Mt CO_2 in 1990 to 94 Mt CO_2 in 2016. Furthermore CO_2 emissions from the 1.B sector decreased by 65% from 458 kt in 1990 to 161 kt in 2016, as well as CH_4 emissions from 1.B sectors decreased by 66% from 456 kt in 1990 to 155 kt in 2016. GHG emission trend from sector Energy for 1990 to 2016 is depicted on Fig. 2-3 (CHMI 2018).

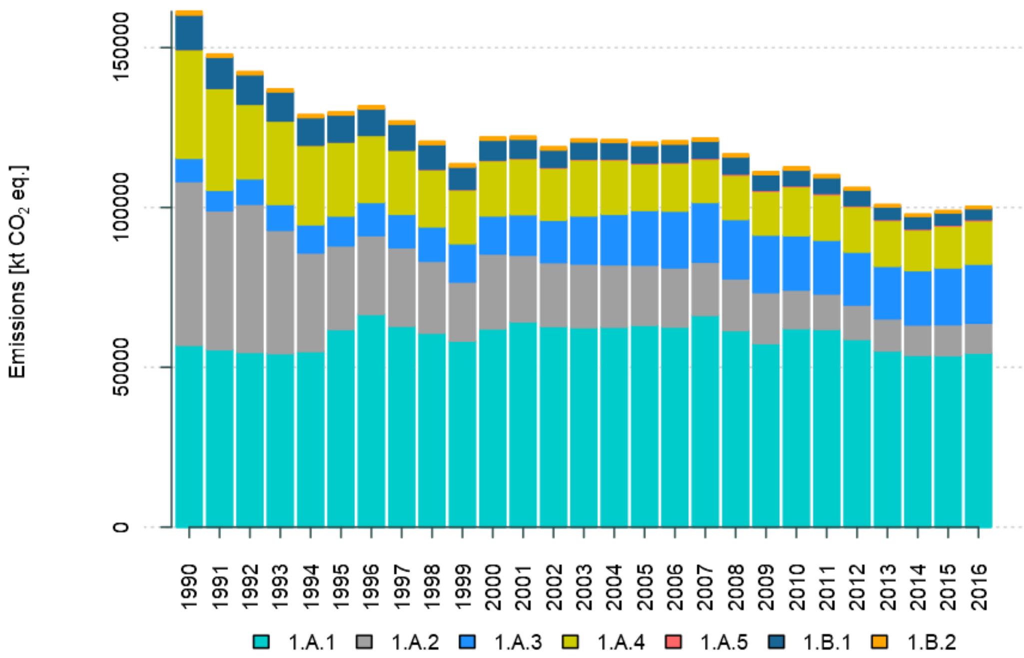

Fig. 2-3 The emission trend in Energy during reporting period 1990 – 2016 (CHMI 2018)

Projections of greenhouse gas emissions from sector 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 by using model Message
- 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 Methodological issues – Energy excluding 1.A.3 Transport

The bottom-up MESSAGE (Model for Energy Supply Strategy Alternatives and their General Environmental Impacts) model was used for the projections of CO_2, CH_4 a N_2O emissions from categories under Energy sector (except of the category 1.A.3 Transport). The model was developed at IIASA (International Institute for Applied Systems Analysis) and designed for the optimization of energy system. The original purpose of MESSAGE was the modelling of energy systems for the International Atomic Energy Agency. Through a set of constraints the model currently calculates also emissions of greenhouse gases and basic pollutants. Therefore no modifications performed for climate change purposes are necessary.

The main principle of the MESSAGE is optimization of an objective function under a set of constraints:

$$OF = \sum(Inv + Fuel + Fixj + Varj + ECj + ETj) = min!$$

where OF is objective function (total cost); Inv, Fuel is investment and fuel cost; Fix, Var is fixed and variable cost; EC and ET is emission and emission trading cost.

The objective function indicates how much each variable contributes to the value to be optimized. For the modelling of emission projections the result of OF is the total cost. The total cost is in this case minimized, which means that the lowest value for the total cost is calculated, e.g. for electricity production the power plants with the lowest investment, fuel and other costs are chosen.

Investment cost (Inv) represent the amount of money spent for building certain production facility (e.g. power plant). The investments include the expenditure accumulated until the start-up of an installation (e.g. power plant). Investment costs include delivery of the installation, construction, civil works, engineering and consulting, license fees, land requirement and capital.

The annual fixed expenditures (Fix) cover the costs of maintenance of the installation and administrative work. The variable operating costs (Var) relate to the actual operation of the plant and take into account additional labour demand, increased energy demand for operating the device or sorbent material demand (e.g., limestone).

Emission costs (EC) are related to tonnes of basic pollutants (BP) emissions emitted per year. These costs are required by responsible environmental authority. Emission trading cost (ET) refers to the sale or purchase of CO_2 allowances under the EU emissions trading system (EU ETS) system.

MESSAGE is a physical flow model. It assures sufficient supply, utilizing the technologies and resources considered. MESSAGE allows modelling of all steps in the energy flows from supply to demand, which is generally referred to as energy chain and steps are called levels (IIASA 2009). Fig. 2-4 shows the schematic representation of some energy chains.

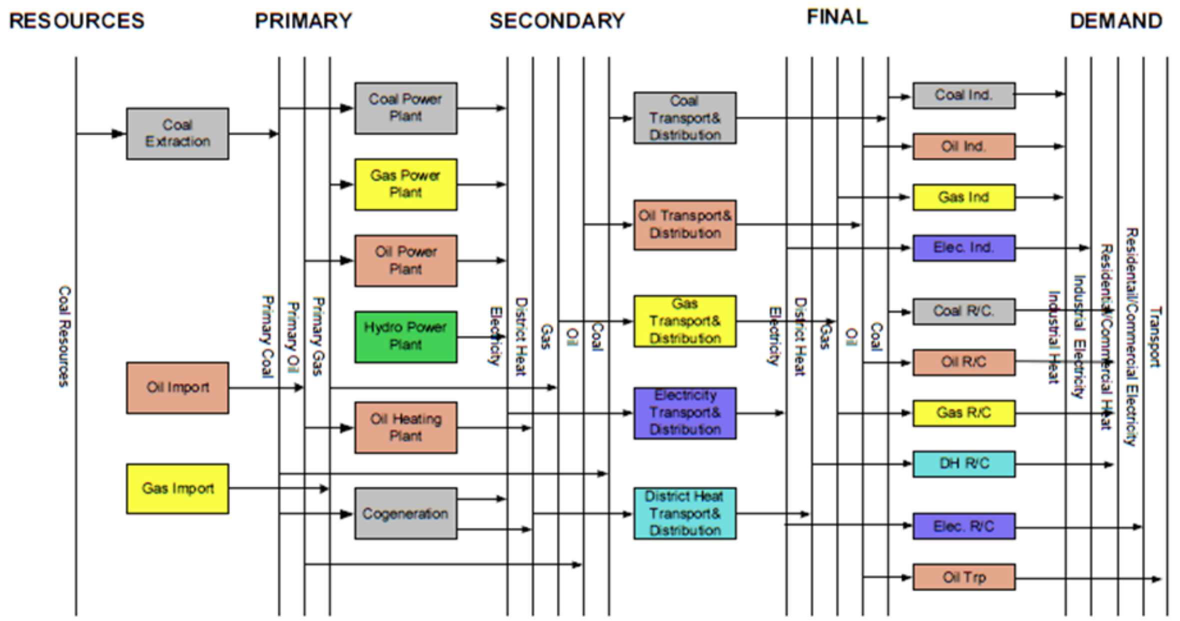

Fig. 2-4 Schematic presentation of energy flows in the MESSAGE model

The basis of MESSAGE is the detailed description of the energy system being modelled. This includes the definition of energy forms at each level of energy chains. Further, technologies that are producing or using these energy forms and the energy resources have to be defined (IAEA 2016).

The model uses input data for individual emission sources from the EU ETS database (e.g. emissions, fuel consumption and fuel parameters). Electricity, heat production and financial support of renewable sources are provided by Energy regulatory office. Energy or industrial companies are directly contacted by the Ministry of Industry and Trade (MIT) and by the Czech Hydrometeorological Institute (CHMI) to get information about future plans (constructions of new sources or shutdowns), technical details, life expectancy, investment and operating costs. The Ministry of Industry and Trade (The State Energy Policy) and OTE, Inc. provide information regarding the development of energy production and consumption. Further data are obtained from the association for energy information and statistics (ENERGOSTAT). MIT and CHMI regularly meet to exchange their information about emission sources and energy production and consumption.

The strength of the model is its flexibility regarding all input data and the possibility to calculate not only activity data and emissions, but also to estimate the influence of various PaMs. The weakness of the model is the complicated inserting of input data, which is time intensive.

Following activities were included in calculation of emission projections for the individual greenhouse gases:

- **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; mining, storage, transport and distribution of natural gas and mining, storage, transport and refining of petroleum,
- **N_2O –** combustion of fuels in stationary sources.

Following initial assumptions were taken into account for projections of greenhouse gas emissions in categories under Energy sector (except the category 1.A.3 Transport):

- **Scenario of demographic trends -** Predictions of the number of inhabitants are based on information from the Czech Statistical Office (CzSO 2014); the number of households, which is also required for calculation of energy demand, was provided by Ministry of Industry and Trade (MIT).
- **Scenario of economic development** - The trends in gross value added in individual sectors were provided by OTE Ltd.

Tab. 2-9 Projection of trends in gross value added (constant prices of 2016) in bill. €

[bill. € '2016]	1995	2000	2005	2010	2016	2020	2025	2030	2035	2040
Industry	18.9	24.6	33.2	42.4	33.0	35.6	38.0	40.3	42.4	44.5
Construction	11,3	7,8	9.2	9.7	9.2	10.1	11.4	12.6	13.8	14.9
Agriculture	2.6	2.5	3.1	2.4	3.1	3.5	3.9	4.2	4.4	4.7
Transport	8.2	8.6	8.9	8.7	7.7	8.9	10.3	11.7	13.0	14.4
Services	53.7	59.0	70.0	78.4	90.1	103.3	120.6	139.0	158.3	179.1
Total	**94.7**	**102.5**	**124.4**	**141.7**	**143.0**	**161.5**	**184.1**	**207.7**	**232.0**	**257.6**

Source: Ote Ltd.

- **Scenario of trends in global prices of fuel and energy -** Petroleum, natural gas and black coal are commonly traded energy commodities on the global market. Price trend scenarios are also regularly prepared for these three basic energy commodities. Recently, electrical energy has been increasingly traded; however, because of the regional character of trade, no scenarios have been published for price trends. The prices of fuels on the global market were taken from the European Commission document "EC_ recommendations parameters projections 2019, Final 15/06/2018".

Tab. 2-10 Global prices of fuels (€/GJ, constant prices of 2016)

€ (2016)/GJ	2010	2015	2020	2025	2030	2035	2040
oil	9.3	6.8	11.9	15.7	17.3	18.1	19.1
gas	5.9	4.7	7.6	9.6	10.5	11.2	11.6
coal	2.5	2.2	2.2	3.2	3.8	4.0	4.2

Source: EC_ recommendations parameters projections 2019, Final 15/06/2018

- **Scenario of trends in domestic prices and availability of fuel and energy -** The prices of imported primary energy sources are based on the above-listed average import prices into the EU (Tab. 2-10). The prices of domestic energy sources are based on the costs of their acquisition and will also be affected by the position of the given fuel in the market compared to competitive energy sources. Solid fuels, especially brown coal, will continue to be a decisive domestic primary energy source by 2020. The purchase prices of electricity from renewable energy sources and from sources with combined heat and electricity production were stipulated by a Decree of the Energy Regulation Authority[3]. The legislation[4] guaranteed favorable purchase prices for a period of 15 years from bringing the source into operation. The Energy Regulatory Office could reduce these prices by up to 5% annually compared to the previous year. The projections assumed maintenance of current purchase prices for the entire period.
  During 2010 investment costs of photovoltaic panels decreased dramatically and extreme boom of new solar installations occurred. The installed capacity of photovoltaic power plants tripled and reached 1800 MW by the end of 2010. Because this sharp increase would have led to a substantial increase of electricity prices, a new law was adopted which enabled to decrease the feed-in tariff by 50 % and a new tax of 26 %, applicable for 3 years for solar power plants built in 2009 and 2010, was introduced. Since 2015, the operational RES support for new installations is only granted to the CHP plants and partially biogas and hydro installations.
- **Scenario of the availability of domestic coal -** Solid fuels, especially brown coal, will continue to be a decisive domestic primary energy source in the near future. These sources will depend on the binding nature of administrative territorial environmental limits on brown coal mining. Tab. 2-11 shows the updated trends in the capacities of mining. The update respects the Governmental decision 827/2015, which partially releases territorial environmental limits at the Bílina mine and keeps them at the ČSA mine. As regards brown coal prices, they are moving from the costs-based price to a price derived from hard coal prices. It is expected that the brown coal price will reach about 75 % of hard coal price.

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[3] *ERA Price Decisions, stipulating the subsidies to supported energy sources (https://www.eru.cz/elektrina/cenova-rozhodnuti, in Czech language)*

[4] *Act No. 165/2012 Coll., on the promotion of production of electricity and from renewable energy sources and on amendment to some laws (Act on Promotion of Use of Renewable Sources)*

Quite dramatic development is observed in hard coal mining. Hard coal mining becomes cost ineffective and the mining company OKD shortened economically exploitable reserves. Moreover, in 2016 the OKD Company (e.g. mines Karvinna – Lazy, Darkov and Paskov) filed bankruptcy. The insolvency proceedings were kept off after all but the future of domestic hard coal mining is not very clear.

Tab. 2-11 Projections of domestic coal mining

Brown coal [thousand t] (Name of mine)	**2016**	**2020**	**2025**	**2030**	**2035**	**2040**
Libous	11958	12000	9500	9500	5000	0
Bilina	9486	9600	8500	7500	7000	4500
CSA	3185	3600	0	0	0	0
Vrsany	6335	7500	6140	6140	6140	6140
Jiri and Druzba	7627	6000	6000	6000	6000	0
Centrum	55	0	0	0	0	0
Total	**38646**	**38700**	**30140**	**29140**	**24140**	**10640**
Hard coal [thousand t] (Name of mine)	**2016**	**2020**	**2025**	**2030**	**2035**	**2040**
CSM	2400	2650	0	0	0	0
Karvinna - CSA	1300	1600	0	0	0	0
Karvinna - Lazy	800	0	0	0	0	0
Darkov	1300	0	0	0	0	0
Paskov	765	0	0	0	0	0
Total	**6565**	**4250**	**0**	**0**	**0**	**0**

Source: MIT

- **Price of emission allowances -** As recommended by the European Commission in "EC_ recommendations parameters projections 2019, Final 15/06/2018", the following carbon prices were used (expressed in constant prices of 2016):

- ***Tab. 2-12 EU ETS carbon price***

€2016/tCO_2	**2016**	**2020**	**2025**	**2030**	**2035**	**2040**
EU ETS carbon price	5.8	15.5	23.3	34.7	43.5	51.7

Source: EC_ recommendations parameters projections 2019, 15/06/2018

- **Energy production scenario -** The energy consumption and production scenario of the projections is in compliance with the State Energy Policy (MIT 2015a) and with the draft of the energy-climate plan of the Czech Republic (MIT 2019). The scenarios evaluated in the frame of the State Energy Policy were based on three priorities: safety – sustainability – competitiveness. There were set constrains for the acceptable development of the primary energy mix and electricity generation. Various scenarios within these constrains were analyzed. The "Optimized scenario" represents the most presumable energy system development. The most important assumptions were used for model calculations of greenhouse gas emissions:

- The Temelin nuclear power plant will remain in normal operation for the whole monitored period (2000 – 2035).
- The operation license for the Dukovany nuclear power plant will be prolonged and the power plant decommissioned gradually in the period 2035 – 2037.
- The tender for new nuclear units in the nuclear power plant Temelin was cancelled and possible introduction of new nuclear units was postponed to and after the year 2030.
- The territorial environmental limits on mining of brown coal will be retained at the ČSA mine and partly relaxed at the Bílina mine.
- No limits will be introduced on the import of petroleum, gas and hard coal.
- Imports and exports of electricity will be limited by technical capabilities of transmission lines.

2.2.1.1 Fuel Combustion

GHG emissions from fuel combustion are calculated by the MESSAGE model. The model energy outputs are in compliance with the Czech Statistical Office energy balance, the State Energy Policy (MIT 2015a) and the new energy production and consumption projections provided by the Ministry of Industry and Trade (MIT).

2.2.1.1.1 Gross inland consumption

After 2016 the domestic consumption of primary energy sources (PES) slightly increases. A high growth can be noted by renewable energy sources (RES) and by the energy from waste. Domestic consumption of coal strongly decreases and even the usage of gaseous fuel shows a descending development. The energy saving measures partially compensate the energy consumption growth driven by the growing economy in the following periods.

The RES share develops in accordance with the State Energy Policy (MIT 2015a) and with the draft of the energy-climate plan of the Czech Republic (MIT 2019). The biggest role among RES plays and will play biomass. The consumption of biogas is also expected to growth.

Tab. 2-13 Domestic consumption of primary energy sources

Domestic consumption of primary energy sources [PJ]	**2016**	**2020**	**2025**	**2030**	**2035**	**2040**
Coal	694	661	540	530	451	279
Crude oil and oil products	335	370	373	370	368	361
Gaseous fuels	294	290	293	284	275	330
Renewable energy	180	200	218	239	246	254
Nuclear fuel	263	339	340	340	395	464
Other	-27	-43	-13	-13	-6	8
TOTAL	1739	1817	1751	1750	1729	1696

Source: CzSO and MIT (MIT 2019)

Tab. 2-14 Domestic consumption of renewable energy sources

Domestic consumption of renewable energy sources [PJ]	**2016**	**2020**	**2025**	**2030**	**2035**	**2040**
Hydro energy	7	7	7	7	7	7
Wind energy	2	2	3	7	9	11
Solar electricity	8	8	9	11	11	12
Solar heat	1	1	1	2	2	2
Geothermal energy		0	0	2	3	4
Biomass	122	133	142	153	157	162
Biogas	25	26	28	29	29	29
Wastes renewable	4	4	8	9	9	9
Bioethanol	2	3	3	3	3	2

Domestic consumption of renewable energy sources [PJ]	2016	2020	2025	2030	2035	2040
Biodiesel	11	15	16	17	17	17
TOTAL	**180**	**200**	**218**	**239**	**246**	**254**

Source: CzSO and MIT (MIT 2019)

2.2.1.1.2 Final energy consumption

The projection of the total final energy consumption shows a slight decrease. The main drop is presumed for coal whereas renewables consumption is expected to be growing. Also the final consumption of electricity will increase.

Tab. 2-15 Final energy consumption

Final energy consumption [PJ]	2016	2020	2025	2030	2035	2040
Coal	69	59	46	37	30	28
Manufactured gases	13	12	12	11	11	11
Oil and petroleum products	271	269	271	268	266	260
Natural gas	221	219	215	206	205	203
Renewables and biofuels	117	129	141	153	155	149
Non-renewable waste	10	10	10	10	10	10
Nuclear heat						
Derived heat	89	89	85	81	78	75
Electricity	202	214	219	224	229	237
TOTAL	**992**	**1002**	**999**	**990**	**983**	**972**

Source: CzSO and MIT

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 houses. With the current trend we may expect that the main insulation process will be finished between years 2015 – 2020. After 2015 the new building standards drive further decline of energy consumption in households. Around 2020 starts the second insulation round due to the ending of the lifetime of insulations installed in the first round. On the other hand the electricity consumption is supposed to growth despite increasing efficiency of appliances due to lower appliances ownership ratios in comparison with more developed countries.

Tab. 2-16 Final energy consumption of households

Final energy consumption in households [PJ]	2016	2020	2025	2030	2035	2040
Coal	0.031	0.027	0.022	0.017	0.011	0.010
Liquid fuels	0.002	0.002	0.002	0.002	0.002	0.002
Natural gas	0.083	0.080	0.074	0.068	0.061	0.059
Renewables	0.075	0.080	0.087	0.094	0.100	0.093
Heat	0.044	0.043	0.042	0.031	0.041	0.039
Electricity	0.054	0.055	0.057	0.059	0.062	0.064
TOTAL	**0.290**	**0.288**	**0.285**	**0.281**	**0.277**	**0.267**

Source: CzSO and MIT

Regarding final consumption in industry a moderate increase by 3 PJ in 2040 in comparison to 2016 is expected. The coal and electricity consumption during this period decreases whereas renewables, natural gas and heat consumption increases.

Tab. 2-17 Final energy consumption of industry

Final energy consumption in industry [PJ]	2016	2020	2025	2030	2035	2040
Coal	29	28	21	19	19	18
Technological gases	13	12	12	11	11	11
Liquid fuels	6	7	7	6	6	6

Final energy consumption in industry [PJ]	2016	2020	2025	2030	2035	2040
Natural gas	84	88	91	90	89	88
Renewables	20	22	23	23	23	23
Industrial waste	9	9	9	9	9	9
Electricity	25	27	26	23	22	22
Heat	84	91	95	97	97	98
TOTAL	**270**	**284**	**283**	**278**	**276**	**274**

Source: CzSO and MIT

For the commercial sector and other 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 low decline.

Tab. 2-18 Final energy consumption of commercial, agriculture/fisheries and other

Final energy consumption in services [PJ]	2016	2020	2025	2030	2035	2040
Coal	2	1	1	0	0	0
Technological gases	0	0	0	0	0	0
Liquid fuels	17	16	16	16	16	16
Natural gas	51	49	46	43	40	36
Renewables	9	9	9	9	9	9
Industrial waste	1	1	1	1	1	1
Municipal waste	1	1	1	1	1	1
Heat	19	19	18	17	17	16
Electricity	59	61	60	59	58	56
TOTAL	158	154	150	144	140	133

Source: CzSO and MIT

The final energy consumption in transport shows a slight increase as a result of trade-off between increasing mobility and improving energy efficiency of transport vehicles.

Tab. 2-19 Final energy consumption in transport

Final energy consumption in transport [PJ]	2016	2020	2025	2030	2035	2040
Liquid fuels	248	252	256	255	253	248
Natural gas	2	4	8	16	21	26
Renewables	13	13	13	13	13	13
Electricity	6	7	8	10	14	20
TOTAL	**269**	**276**	**285**	**294**	**301**	**307**

Source: CzSO and MIT

2.2.1.1.3 Electricity generation

The total electricity generation from coal is decreasing. Gas, nuclear energy and renewable energy overtake the role of coal. The first new nuclear unit is planned for the year 2033 as partial replacement of the nuclear power plant Dukovany, which will be decommissioned in the period 2035 – 2037.

Tab. 2-20 Structure of electricity generation

Structure of electricity generation [PJ]	2016	2020	2025	2030	2035	2040
Coal	151	148	117	117	93	50
Technological gases	10	10	10	10	10	3
Liquid fuels	0	0	0	0	0	0
Natural gas	13	14	15	14	14	31
Renewables	38	40	44	50	52	56
Industrial waste	0	0	0	0	0	0

Structure of electricity generation [PJ]	2016	2020	2025	2030	2035	2040
Municipal waste	0	0	1	1	1	1
Nuclear energy	87	112	112	112	130	153
TOTAL	**213**	**213**	**187**	**193**	**171**	**141**

Source: CzSO and MIT

Due to preferential feed-in tariffs for electricity produced from renewable energy sources, namely electricity from photovoltaic panels, there was an extremely rapid increase of photovoltaic electricity production up to year 2010. Since the rapid growth of photovoltaic power plants caused a significant increase of electricity price, the government adopted measures to cut further installations of big photovoltaic plants after the year 2010. Further development of renewable energy sources is in accordance with the State Energy Policy (MIT 2015a) and with the draft of the energy-climate plan of the Czech Republic (MIT 2019).

Tab. 2-21 Structure of electricity generation from renewable energy

Structure of electricity generation [PJ]	2016	2020	2025	2030	2035	2040
Hydropower	12	11	11	12	12	12
Wind power	2	2	3	7	9	11
Solar energy	8	8	9	11	11	12
Geothermal energy	0	0	0	0	1	1
Biomass	7	8	8	8	8	9
Biogas	9	10	10	11	11	11
Biodegradable waste	0	0	1	1	1	1
TOTAL	**38**	**40**	**44**	**50**	**52**	**56**

Source: CzSO and CHMI

2.2.1.1.4 District heat generation

As the demand for district heat, mainly in households, sinks the total district heat generation decreases. Heat generation from coal remains crucial for heat supply of households and so the coal share, in contrast to electricity generation, does not decline so quickly. District heat generation from natural gas is increasing.

Also the RES share in heat generation shows a fast growth with biomass being the main driver. The increasing amount of biomass will be covered by energy crops and plants.

Tab. 2-22 Structure of district heat generation

Structure of heat generation [PJ]	2016	2020	2025	2030	2035	2040
Coal	72	69	57	55	52	25
Technological gases	6	6	6	6	6	5
Liquid fuels	1	1	1	1	1	1
Natural gas	35	36	38	33	28	50
Renewables	9	10	15	19	23	25
Industrial waste	0	0	0	0	0	0
Municipal waste	1	1	3	4	4	4
Nuclear energy	1	1	1	1	2	3
TOTAL	**126**	**125**	**122**	**118**	**116**	**112**

Source: CzSO and CHMI

2.2.1.2 Fugitive Emissions

The calculation of fugitive emissions is based on the results of the MESSAGE model and includes methane leakages from deep and open coal mines, crude oil mining and cracking, natural gas leakages from mining, transmission a distribution of natural gas and natural gas leakages from power plants and heating plants. The implied emission factors from the National Inventory Report (CHMI 2018) were used.

2.2.2 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 is supposed to continue also in the period 2010 – 2020. On the other hand, improved efficiency of new cars causes that energy consumption will reach its peak around the year 2015 and then it will be slightly decreasing.

In 2016, the total emissions from Transport (1.A.3) were 18, 449.82 kt CO_2 eq. Emissions increased by 153% compared to the year 1990 (CHMI 2018). GHG emission trend from Transport for 1990 to 2016 is depicted on Fig. 2-5

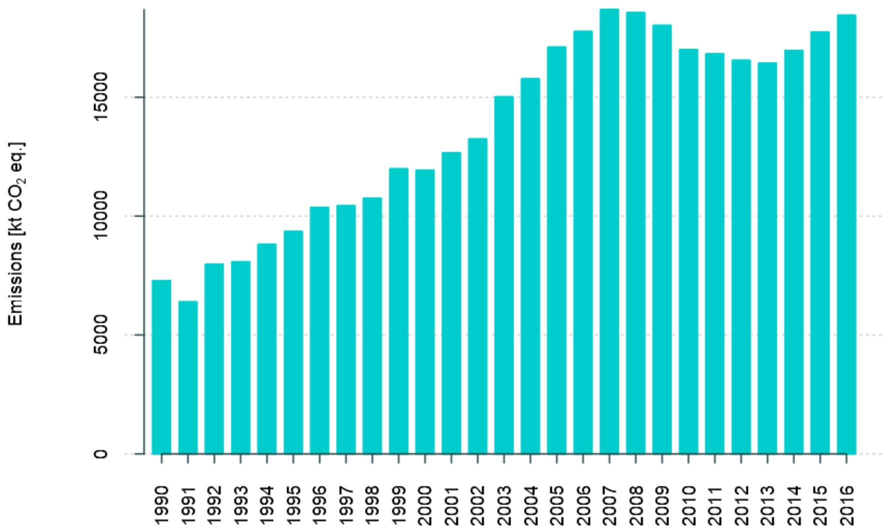


Fig. 2-5 The emission trend in Transport during reporting period 1990 – 2016 (CHMI 2018)

The projected structure of energy carriers in the transport sector is shown in Tab. 2-24. The projection counts with growing shares of bio fuels (up to 2020) and natural gas use. A significant increase of electric and hybrid cars is supposed to start after the year 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 SW COPERT for the period 2000 - 2016 into less detailed categories (aggregation type - sum). COPERT has a total of 372 categories of SRAs, the projection cannot be performed for such a number of categories. Aggregation took into account the mode of transport, the fuel used and the EURO emission standard. The original 372 COPERT categories have been aggregated to 68 ones.
- Updating data on new registrations and discarded vehicles.

- Breakdown of new registrations into vehicle categories, based on the energy consumption forecast, taking into account the data from Ministry of Industry and Trade.
- Distribution of discarded vehicles into older vehicle categories so that their number is continuously falling to zero as part of ongoing fleet renewal.
- Calculation of future vehicle numbers for each year (2017 - 2040), based on the balance of the new registration and discarded vehicles.
- Aggregation of annual kilometric runs from COPERT delivered over the period 2000 - 2016, into own categories (aggregation type - average). Categories are the same (68) as ones in vehicle fleet.
- Trends in km of annual mileages in the 2017 - 2040 projection period, based on prolongation of current trends.
- Calculation of future transport performance over the period 2017 - 2040 for given vehicle categories.
- 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 the methane and nitrous oxide.

With regards to emission reductions by the application of individual policies and measures (for more details please see chapter 1.2.3, only quantified measures has been calculated. Calculable measures are described in following table.

Tab. 2-23 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	CO_2 emissions factors for new passenger cars (average 95 g/km)
Regulation on CO_2 from vans	CO_2 emission factors for new vans (average 147 g/km)
ICAO agreement	No changes from the previous projections (CHMI 2017)
Modal shift	Reduced road freight transport performance with an estimated share of trips of more 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

Tab. 2-24 Projection of final energy consumption of the transport sector

Final energy consumption in transport [PJ]	2012	2016	2020	2025	2030	2035	2040
Brown coal	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Liquid biofuels	11.5	19.7	29.1	29.1	28.1	28.1	28.1
Electricity	8.0	8.0	9.7	12.1	15.6	20.4	22.6
Gasoline	68.7	65.9	53.9	50.2	50.5	46.7	42.4
Diesel fuel	146.9	143.0	119.5	99.6	92.4	95.7	90.4
Aviation fuels	13.2	13.4	15.6	16.4	16.7	17.2	17.2
Liquefied petroleum gas	3.1	3.2	2.6	2.7	3.8	3.6	3.6
Natural gas	1.8	5.3	23.8	35.1	44.1	48.1	48.1

Final energy consumption in transport [PJ]	2012	2016	2020	2025	2030	2035	2040
Hydrogen	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	**253.2**	**258.5**	**254.1**	**245.2**	**251.1**	**259.8**	**252.4**

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

According to the projections of greenhouse gas emissions in 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.3 Transport but difference between WEM and WAM scenario is not very distinctive. For year 2040, the difference between WEM and WAM scenario is calculated to 0.29 Mt CO_2 eq.

In total numbers it is expected that GHG emissions from Energy sector will decrease approximately by 58% in 2040 compared to year 1990, by 44% compared to year 2005 and by 33% compared to current level of emissions for WEM scenario. Similar percentage differences are calculated also for the WAM scenario.

Tab. 2-25 Reported and projected emissions of GHG in Energy sector – WEM and WAM

	Reported emissions			Projected emissions					Difference [%]		
[Mt CO_2 eq.]	1990	2005	2016	2020	2025	2030	2035	2040	1990 – 2020	1990 – 2030	1990 – 2040
WEM	161.34	120.35	100.28	96.49	85.66	82.15	73.03	67.59	-40.20	-49.08	-58.11
WAM	161.34	120.35	100.28	96.15	85.28	81.78	72.69	67.29	-40.41	-49.31	-58.29

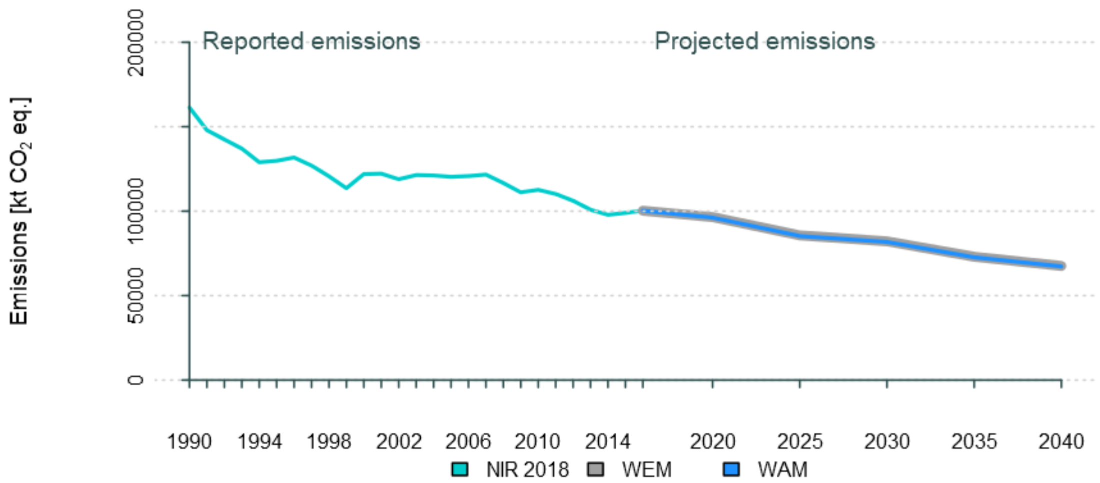


Fig. 2-6 Reported and projected emissions of GHG in Energy – WEM, WAM

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

The Energy sector is source of CO_2, CH_4 and N_2O emissions. It is expected that emissions are going to decrease for all gases emitted by Energy sector during projected period. It is expected that in 2040 CO_2 emissions will decrease by 33%, CH_4 by 28% and N_2O by 41% compared to current level of emissions.

Tab. 2-26 Breakdown of reported and projected emissions of GHG by gases in transport - WEM scenario

	Reported emissions			Projected emissions					Difference [%]		
[Mt CO_2 eq.]	**1990**	**2005**	**2016**	**2020**	**2025**	**2030**	**2035**	**2040**	**1990 – 2020**	**1990 – 2030**	**1990 – 2040**
CO_2	147.26	112.64	94.58	90.99	80.37	77.43	68.45	63.60	-38.21	-47.42	-56.81
CH_4	13.24	6.90	4.85	4.86	4.69	4.13	4.04	3.48	-63.27	-68.78	-73.69
N_2O	0.83	0.81	0.85	0.63	0.60	0.59	0.54	0.50	-24.36	-29.23	-39.55
Total	**161.34**	**120.35**	**100.28**	**96.49**	**85.66**	**82.15**	**73.03**	**67.59**	**-40.20**	**-49.08**	**-58.11**

In 2016 the dominant GHG emissions source in the Energy sector is represented by category 1.A.1 Energy Industries (54%), followed by 1.A.3 Transport (18%), 1.A.4 Other Sectors (13%) and 1.A.2 Manufacturing Industries (9%). Emissions from category 1.B Fugitive emissions has 4% share on total emissions from Energy sector. A significant reduction of GHG emissions can be observed in 1.A.2 Manufacturing Industries and 1.A.4 Other Sectors in the past years (Tab. 2-29) (CHMI 2018). This resulted mainly from the switch from domestic coal to other fuels, mainly to gas. As easily accessible domestic reserves of brown coal are getting close to depletion - a similar tendency in 1.A.1 Energy Industries can be assumed.

For all categories under Energy sector except of the category 1.A.2 and 1.B.2 is expected that emissions will decrease in 2040 compared to current level of emissions. The most rapid decrease of emissions can be observed for category 1.A.5 Other sectors but it should be taken into account that this category has only 4% share on total emissions from Energy in 2016 (CHMI 2018). For category 1.A.1 Energy Industries which has major share on total GHG emissions from Energy it is expected that emissions will decrease in 2040 compared to current level of emissions by 38%.

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 higher decrease after the year 2020. This change in electricity generation is a result of depleting reserves of domestic brown coal. Some power plants (PP) are expected to shut down after 2020 (e.g. PP Melnik II, Ledvice II and Prunerov I). In the period between 1990 and 2040 a drop of 40% is projected in the category 1.A.1. In the category 1.A.1.a the decline is even larger – approximately 50%. Construction of new nuclear units is expected after the year 2030. The decrease of GHG emissions is also caused by the increased share of RES in electricity and heat generation.

The final energy consumption in category 1.A.2 Manufacturing industries and construction is slightly increasing. The electricity consumption is, after the crisis related drop in 2010, growing and the share of fossil fuels is decreasing. The drop of GHG emission is 80% in the period 1990 – 2020 and 81% between the years 1990 and 2030 and between the year 1990 and 2040 in the WEM scenario.

In the subcategory 1.A.4 Other sectors high drops up to 74% in 2040 comparing to 1990 are expected to be achieved. In the 1.A.4.a commercial sector even 81% can be reached if all abatement measures will be applied. The highest share in emissions shows the 1.A.4.b Residential sector.

The projections of fugitive emissions are based on fuel quantities calculated using the MESSAGE model. The projected decline in fugitive emissions results mainly from decreasing mining of hard coal.

Tab. 2-27 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	2016	2020	2025	2030	2035	2040	1990 – 2020	1990 – 2030	1990 – 2040
1. Energy	**161.34**	**120.35**	**100.28**	**96.49**	**85.66**	**82.15**	**73.03**	**67.59**	**-40.20**	**-49.08**	**-58.11**
A. Fuel combustion (sectoral approach)	**149.48**	**113.94**	**96.25**	**92.46**	**81.80**	**78.84**	**69.79**	**64.89**	**-38.14**	**-47.26**	**-56.59**
1. Energy industries	56.92	63.17	54.45	51.49	42.54	42.24	36.26	34.02	-9.54	-25.79	-40.23
a. Public electricity and heat production	54.90	56.48	47.66	44.62	35.81	35.66	29.67	27.60	-18.73	-35.04	-49.73
b. Petroleum refining	0.49	0.89	0.41	0.52	0.54	0.50	0.48	0.49	5.48	1.19	-1.09
c. Manufacture of solid fuels and other energy industries	1.52	5.79	6.39	6.35	6.19	6.08	6.11	5.93	317.57	299.80	290.20
2. Manufacturing industries and construction	51.23	18.84	9.40	9.86	9.83	9.68	9.61	9.52	-80.75	-81.11	-81.42
3. Transport	7.28	17.11	18.45	17.94	17.39	16.10	14.27	12.22	146.36	121.04	67.76
a. Domestic Aviation	0.14	0.01	0.01	0.01	0.01	0.01	0.01	0.01	-93.67	-93.60	-93.57
b. Road Transportation	6.35	16.70	18.06	17.54	16.99	15.71	13.88	11.83	176.24	147.32	86.25
c. Railways	0.73	0.32	0.31	0.28	0.26	0.24	0.22	0.22	-62.01	-67.46	-70.11
d. Domestic Navigation	0.06	0.02	0.01	0.03	0.04	0.06	0.08	0.08	-49.69	5.98	33.82
e. Other Transportation	0.01	0.07	0.06	0.08	0.08	0.08	0.08	0.08	1447.42	1446.29	1449.07
4. Other sectors	34.04	14.55	13.55	12.94	11.82	10.59	9.43	8.90	-62.00	-68.88	-73.85
a.Commercial/ institutional	10.08	3.53	2.87	2.88	2.64	2.40	2.17	1.96	-71.47	-76.18	-80.52
b. Residential	20.01	9.68	9.43	8.91	8.00	7.01	6.00	5.69	-55.46	-64.99	-71.56
c.Agriculture/ forestry/fishing	3.95	1.34	1.24	1.15	1.18	1.19	1.26	1.25	-70.94	-69.95	-68.37
5. Other	NO	0.27	0.41	0.23	0.23	0.23	0.23	0.23	NA	NA	NA
B. Fugitive emissions from fuels	**11.86**	**6.41**	**4.03**	**4.03**	**3.86**	**3.31**	**3.24**	**2.70**	**-66.06**	**-72.10**	**-77.24**
1. Solid fuels	10.78	5.51	3.42	3.38	3.07	2.68	2.58	2.02	-68.66	-75.18	-81.31
2. Oil and natural gas and other emissions from energy production	1.08	0.90	0.61	0.65	0.79	0.63	0.65	0.69	-40.14	-41.45	-36.70
C. CO2 transport and storage	NO	NO	NO	NO	NO	NO	NO	NO	NA	NA	NA

2.2.3.2 'With additional measures (WAM) scenario'

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. 2-28 and Fig. 2-7). 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. 2-28 Reported and projected emissions of GHG in transport – WEM and WAM

	Reported emissions			Projected emissions					Difference [%]		
[Mt CO_2 eq.]	**1990**	**2005**	**2016**	**2020**	**2025**	**2030**	**2035**	**2040**	**1990 – 2020**	**1990 – 2030**	**1990 – 2040**
WEM	7.28	17.11	18.45	17.94	17.38	16.10	14.27	12.22	146.36	121.04	67.76
WAM	7.28	17.11	18.45	17.60	17.01	15.73	13.93	11.92	141.66	115.92	63.67

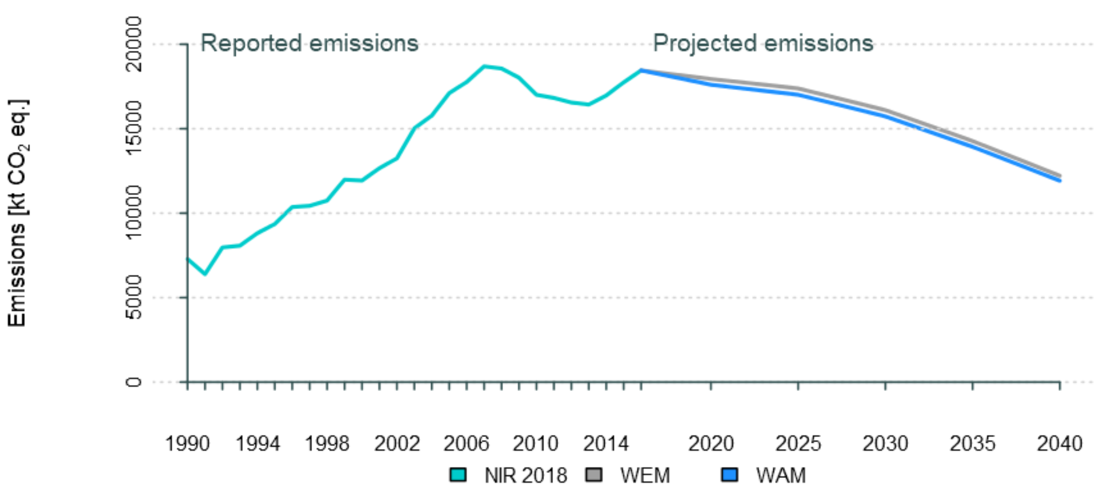


Fig. 2-7 Reported and projected emissions of GHG in Transport – WEM, WAM

Following tables contain breakdown of reported and projected emissions by gases and by categories for WEM scenario. According to the WEM scenario, emissions from Transport should decrease by 34% in 2040 compared to 2016.

Tab. 2-29 Breakdown of reported and projected emissions of GHG by gases in transport - WEM scenario

	Reported emissions			Projected emissions					Difference [%]		
[Mt CO_2 eq.]	**1990**	**2005**	**2016**	**2020**	**2025**	**2030**	**2035**	**2040**	**1990 – 2020**	**1990 – 2030**	**1990 – 2040**
CO_2	7.03	16.72	18.03	17.72	17.15	15.88	14.07	12.04	151.92	125.83	71.28
CH_4	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.03	-30.43	-29.38	-28.97
N_2O	0.21	0.35	0.39	0.20	0.20	0.19	0.17	0.15	-6.08	-10.90	-32.05
Total	**7.28**	**17.11**	**18.45**	**17.94**	**17.38**	**16.10**	**14.27**	**12.22**	**146.36**	**121.04**	**67.76**

Tab. 2-30 Breakdown of reported and projected emissions of GHG by categories in transport - WEM scenario

[Mt CO_2 eq.]	Reported emissions			Projected emissions					Difference [%]		
	1990	2005	2016	2020	2025	2030	2035	2040	1990 – 2020	1990 – 2030	1990 – 2040
1.A.3.a Domestic Aviation	0.14	0.01	0.01	0.01	0.01	0.01	0.01	0.01	-93.67	-93.60	-93.57
1.A.3.b Road Transportation	6.35	16.70	18.06	17.54	16.99	15.71	13.88	11.83	176.24	147.32	86.25
1.A.3.c Railways	0.73	0.32	0.31	0.28	0.26	0.24	0.22	0.22	-62.01	-67.46	-70.11
1.A.3.d Domestic Navigation	0.06	0.02	0.01	0.03	0.04	0.06	0.08	0.08	-49.69	5.98	33.82
1.A.3.e Other Transportation	0.01	0.07	0.06	0.08	0.08	0.08	0.08	0.08	1447.42	1446.29	1449.07
Total	**7.28**	**17.11**	**18.45**	**17.94**	**17.38**	**16.10**	**14.27**	**12.22**	**146.36**	**121.04**	**67.76**

It is projected, that additional measures *Economic tax tools* and *Road tool* will influence GHG emissions from transport as it is shown in following tables. According to the WAM scenario, emissions from Transport should decrease by 35% in 2040 compared to 2016.

Tab. 2-31 Breakdown of reported and projected emissions of GHG by gases in transport - WAM scenario

[Mt CO_2 eq.]	Reported emissions			Projected emissions					Difference [%]		
	1990	2005	2016	2020	2025	2030	2035	2040	1990 – 2020	1990 – 2030	1990 – 2040
CO_2	7.03	16.72	18.03	17.38	16.79	15.52	13.74	11.75	147.16	120.66	67.15
CH_4	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.03	-30.84	-29.69	-29.29
N_2O	0.21	0.35	0.39	0.20	0.20	0.18	0.16	0.14	-8.42	-13.78	-34.39
Total	**7.28**	**17.11**	**18.45**	**17.60**	**17.01**	**15.73**	**13.93**	**11.92**	**141.66**	**115.92**	**63.67**

Tab. 2-32 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	2016	2020	2025	2030	2035	2040	1990 – 2020	1990 – 2030	1990 – 2040
1.A.3.a Domestic Aviation	0.14	0.01	0.01	0.01	0.01	0.01	0.01	0.01	-93.67	-93.60	-93.57
1.A.3.b Road Transportation	6.35	16.70	18.06	17.20	16.62	15.34	13.54	11.53	170.89	141.49	81.61
1.A.3.c Railways	0.73	0.32	0.31	0.28	0.26	0.24	0.22	0.22	-62.01	-67.46	-70.11
1.A.3.d Domestic Navigation	0.06	0.02	0.01	0.03	0.04	0.06	0.08	0.08	-49.69	5.98	33.82
1.A.3.e Other Transportation	0.01	0.07	0.06	0.08	0.08	0.08	0.08	0.08	1447.42	1446.29	1449.07
Total	**7.28**	**17.11**	**18.45**	**17.60**	**17.01**	**15.73**	**13.93**	**11.92**	**141.66**	**115.92**	**63.67**

2.2.4 Sensitivity analysis

2.2.4.1 Sensitivity analysis of combustion processes on GDP

The sensitivity analysis was conducted for CO2 emissions from fuel combustion in energy sector (1.A.). Dependency on economic development was tested (+/- 5% GDP difference) with the MESSAGE model. The following table shows the results.

Tab. 2-33 Sensitivity analysis of combustion processes (1.A.) on GDP (WEM scenario)

	CO2 (Mt)	CO2 in Mt (GDP +5%)	CO2 in Mt (GDP - 5%)	Emission difference in % (GDP +5%)	Emission difference in % (GDP -5%)
2014	96.2	96.2	96.2	0.0	0.0
2015	92.5	98.0	88.6	9.0	-7.4
2020	81.8	89.4	78.9	8.2	-7.1
2025	78.8	83.3	75.6	8.3	-7.6
2030	69.8	76.7	66.9	8.7	-8.0
2035	64.9	64.9	64.9	0.0	0.0

2.2.4.2 Sensitivity analysis of combustion processes on coal price

In this analysis the price of coal was changed (+/- 30%). The model MESSAGE shows no differences due to a higher price of natural gas and to a lower price of biomass (governmental support and no payment for allowances included). Even when the price of coal was changed by +/- 30%, the price of natural gas remained higher and the price of biomass stayed lower than the price of coal.

2.2.4.3 Sensitivity analysis for 1.A.3 Transport

The sensitivity analysis for 1.A.3 was done with a help of Monte Carlo method that relies on repeated random sampling to obtain numerical results. Essential idea of Monte Carlo method is using randomness to solve problems that might be deterministic in principle. 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.

2.2.5 Difference between previously and currently reported projections

There are no significant changes in projections of greenhouse gas emissions from the Energy sector compared to the previous projections. The same model (MESSAGE) was used (except the transport sector). The main change was the tighter cooperation of CHMI with MIT regarding input data for the model, especially the future development of energy sources.

Projections for category 1.A.3 Transport were calculated in R-project unlike previous projections (CHMI 2017). This is related to the fact that COPERT data was available for this reporting for the first time. COPERT data are very detailed and needs 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

The sector of Industrial processes and other product use (IPPU) of GHG emission inventory includes emissions from technological processes and not from fuel combustion used to supply energy for carrying out these processes (CHMI 2018).

In 2016, the total aggregate GHG emissions from industrial processes were 15,221.74 kt of CO_2 equivalents, which represent increase of 2% compared to the previous year. Emissions decreased by 11% compared to the reference year 1990. The major share of CO_2 emissions in this sector comes from sub-source categories 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 2018).

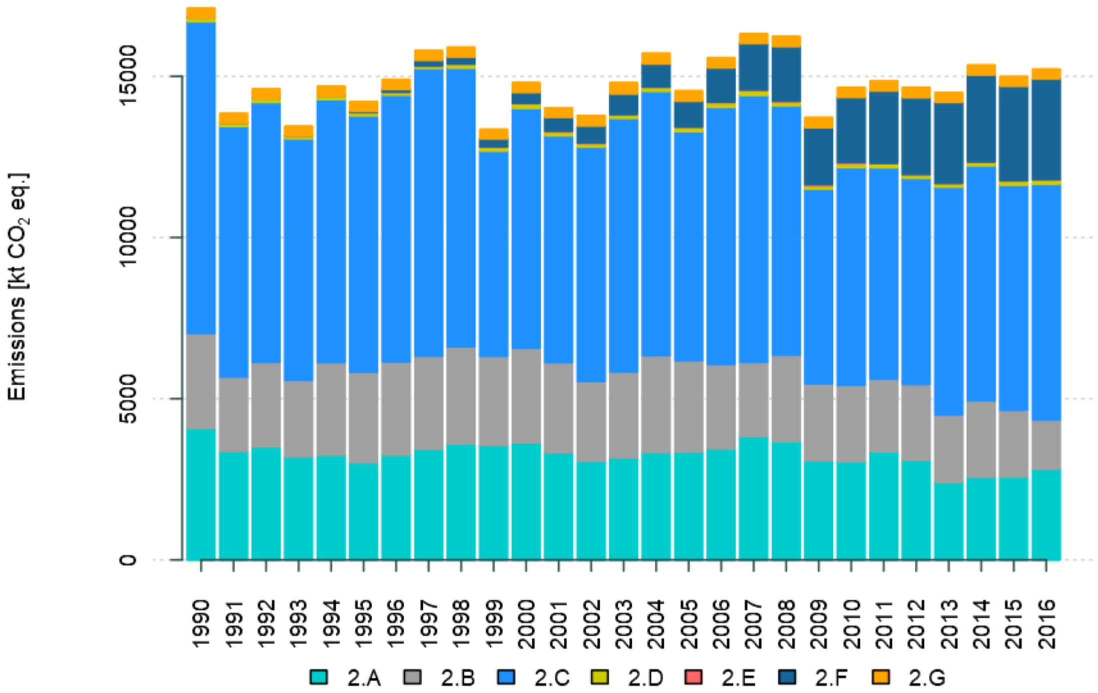


Fig. 2-8 The emission trend in IPPU sector during reporting period 1990 - 2016 (CHMI 2018)

2.3.1 Methodological issues

The projections of greenhouse gas emissions in IPPU are based on data and methodology used for emission estimates reported in National Inventory Report (CHMI 2018).

The projections are estimated separately for each subcategory under IPPU sector and also for each gas. In the Czech Republic, there is no additional measure for IPPU sector and thus only WEM scenario is calculated.

For the better accuracy is as a starting point for the projections taken the trend of data for 1990 - 2016 not only the latest reporting year. In most cases, the projections are implemented directly to calculation sheets used for emission estimates to National Inventory Report (NIR) (CHMI 2018). This approach allows using country specific emission factors and the same, or for some cases, slightly modified methodology (mainly for cases, when Tier 3 methodology is used – in those cases, data are not predicted for each producer/facility but data are predicted for the group of producers/facilities).

For the projections in IPPU is important to project activity data and emission factors. Projected activity data and emission factors are then used for emission estimates for projected period 2017 - 2040.

Projection of activity data:

For most of the categories under 2.A Mineral Production, 2.B Chemical Production and 2.C.1 Iron and Steel Production, the activity data are forecasted by the Ministry of Industry and Trade (MIT). The forecasts of the activity data are available for 2017 - 2030, after 2030 data are forecasted by experts at CHMI. For 2.C.2 - 2.C.7 the data were forecasted using statistical methods by the experts from CHMI. However, the emissions are under the threshold of the significance. For 2.D the data about non-energy use of fuels were forecasted by the experts from CHMI.

There is no official forecast of the consumption of fluorinated greenhouse gases in categories 2.E Electronics Industry, 2.F Substitutes for Ozone Depleting Substances and 2.G Other Product Manufacture and Use and thus the forecast of consumption is based on expert judgement at CHMI. Forecasting of F-gases consumption strictly follows 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 in projections of activity data.

Source of activity data used for projections for each subcategory under IPPU is described in Tab. 2-34.

Projection of emission factors:

Emission projections are based on the same approaches as in NIR, which follows IPCC 2006 Gl. (CHMI 2018, IPCC 2006). In most cases, projection of emission factors are based on the development of emission factors in previous years. Emission factors used for projections are derived as average emission factors for selected period or emission factors are calculated by forecasting methods. In some cases, default emission factors are used for emission estimates in NIR and thus this approach is also used for projections (mainly for Tier 1 methodology and F-gases emission estimates).

Detailed information about emission factors used for projections in subcategories under IPPU is described in Tab. 2-34.

Projection of emissions:

Final projections of emissions for selected subcategory under IPPU are calculated by using projected activity data and emission factors. The approach is in line with IPCC 2006 Gl. (IPCC 2006). For example, projections for category 2.F.1 are calculated by model Phoenix, which is used for emission estimates reported in NIR (Ondrusova, Krtkova 2018, CHMI 2018). Methodology used for emission estimates is Tier 2a (CHMI 2018, IPCC 2006); methodology used for emission projections from 2.F.1 is also Tier 2a (IPCC 2006).

Following table contains detailed information about methodology assumptions which were used for projections under IPPU.

Tab. 2-34 Detailed information about projections for categories or subcategories under IPPU

	Projections 2017- 2040		
Category	**Activity data**	**Emission factors (CHMI 2018, IPCC 2006)**	**Methodology (CHMI 2018, IPCC 2006)**
2.A Mineral Production			
2.A.1 Cement Production	to 2030 from MIT, to 2040 derived from MIT data	Average for 2005 - 2016	Modified Tier 3
2.A.2 Lime Production	to 2030 from MIT, to 2040 derived from MIT data	Average for 2010 - 2016	Modified Tier 3
2.A.3 Glass Production	to 2030 from MIT, to 2040 derived from MIT data	Average for 2010 - 2016	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 - 2016	Modified Tier 3
2.A.4.b Soda Ash Production	Average consumption for 2015 and 2016	Plant specific	Modified Tier 3
2.A.4.d Mineral wool production and flue-gas desulphurisation	Average consumption for 2012 to 2016	Default for mineral wool production, plant specific for desulphurisation	Tier 1 for mineral wool production, Modified Tier 3 for desulphurisation
2.B Chemical Production			
2.B.1 Ammonia Production	to 2030 from MIT, to 2040 derived from MIT data	Default	Tier 1
2.B.2 Nitric Acid Production	to 2030 from MIT, to 2040 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 2040 derived from MIT data	Default	Tier 1
2.B.8.c Vinyl Chloride Monomer	to 2030 from MIT, to 2040 derived from MIT data	Default	Tier 1
2.B.8.f Carbon Black	Average consumption for 2014 to 2016	Default	Tier 1
2.B.8.g Styrene	Average consumption for 2010 to 2016	Plant specific, Default	Modified Tier 3, Tier 1
2.B.10 Other Non-energy Use in chemical Industry	Average consumption for 2010 to 2016	Default, country specific	Tier 1
2.C Iron and Steel Production			
2.C.1 Iron and steel production	to 2030 from MIT, to 2040 derived from MIT data	Default, country specific, plant specific	Tier 2
2.C.2 Ferroalloys production	Average consumption for 2010 to 2016	Default	Tier 1
2.C.5 Lead production	Average consumption for 2010 to 2016	Default	Tier 1
2.C.6 Zinc production	Average consumption for 2010 to 2016	Default	Tier 1
2.D Non-energy products from fuels and solvent use			
2.D.1 Lubricant use	Average consumption for 2010 to 2016	Default	Tier 1
2.D.2 Paraffin wax use	Average consumption for 2010 to 2016	Default	Tier 1
2.D.3 Other	Average consumption for 2010 to 2016	Default	Tier 1

	Projections 2017- 2040		
Category	**Activity data**	**Emission factors (CHMI 2018, IPCC 2006)**	**Methodology (CHMI 2018, IPCC 2006)**
	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 based on previous trend	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 trend and following Regulation No 517/2014, and Kigali Amendment of the Montreal Protocol For 2.F.1.e, vehicle fleet projections obtained from MPO, following Directive 2006/40/EC	Country specific and default	Tier 2a (The model Phoenix was used for projections for subcategories under 2.F.1, except 2.F.1.e. For 2.F.1.e was used country specific approach, more details are in NIR (CHMI 2018))
2.F.2 Foam blowing agents to 2.F.5 Solvents	Projections of consumption are based on previous trends and following 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 for 2013 to 2016	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

2.3.2 Projected greenhouse gas emissions 'With 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. There is no additional measure for IPPU sector and thus only WEM scenario is calculated.

According to WEM scenario, total emissions from IPPU will be slightly increasing and then stagnant in next few years. It is not expected that the production capacity for main products in the Czech Republic as lime, cement, ammonia, iron and steel is going to decrease rapidly. It is expected that the decrease of GHG emissions till 2040 will be very slight and it will be mainly influenced by ban on F-gases use. According to current projections (Tab. 2-35 and Fig. 2-9), it is expected that total emissions from IPPU in 2040 will decrease by 21% compared to year 1990 and by 11% compared to year 2016. Emission projections are based on the current situation in the Czech industry and current legislation, but it is highly possible that during next few years, producers will renovate their units and will introduce new mitigation technics and thus there is a space for reduction of GHG emissions from IPPU.

Tab. 2-35 Reported and projected emissions of GHG in IPPU – WEM

	Reported emissions			Projected emissions					Difference [%]		
[Mt CO_2 eq.]	1990	2005	2016	2020	2025	2030	2035	2040	1990 – 2020	1990 – 2030	1990 – 2040
WEM	17.11	14.55	15.22	16.05	15.35	14.43	13.78	13.60	-6.23	-15.71	-20.52

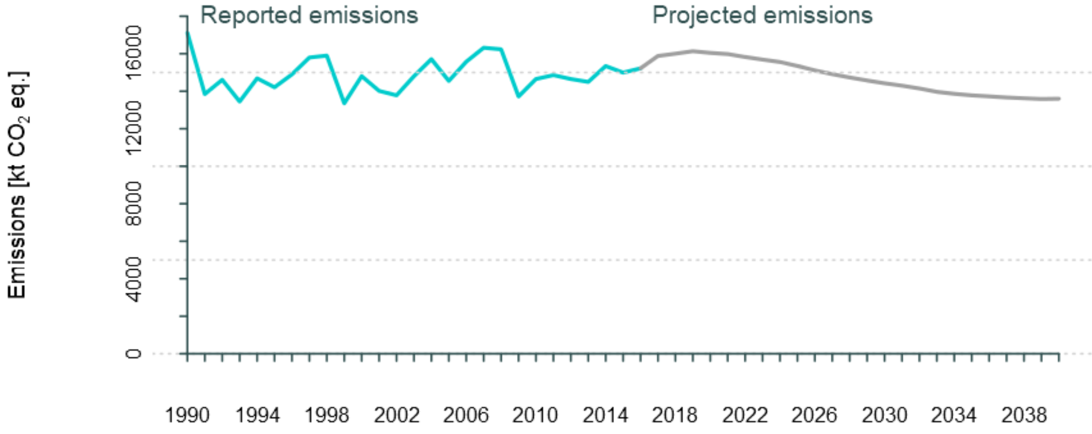


Fig. 2-9 Reported and projected emissions of GHG in IPPU – WEM

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

WEM (with existing measures) scenario takes into account following policies and measures:

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

The breakdown of reported and projected (WEM scenario) emissions by gases is shown in Tab. 2-36. Greenhouse gas with major share on total emissions from IPPU is CO_2. It is expected that emissions of CO_2 will be stagnant during period 2017 - 2040; no major changes are expected in mineral, chemical and metal production and thus emissions will not change rapidly but the small increase of CO_2 emissions compared to current situation is expected. Increase of CH_4 emissions is linked with metallurgical production, mainly with sinter production. Main source of N_2O emissions is nitric acid production and it is expected that production will rise during projected period; production rise is reflected in emissions.

Tab. 2-36 Breakdown of reported and projected emissions of GHG by gases in IPPU - WEM scenario

	Reported emissions			Projected emissions					Difference [%]		
[Mt CO_2 eq.]	1990	2005	2016	2020	2025	2030	2035	2040	1990 – 2020	1990 – 2030	1990 – 2040
CO_2	15.65	12.40	11.48	11.83	11.73	11.68	11.63	11.69	-24.39	-25.33	-25.26
CH_4	0.05	0.06	0.04	0.07	0.07	0.07	0.07	0.07	29.14	30.49	30.38
N_2O	1.33	1.17	0.51	0.64	0.67	0.67	0.67	0.63	-51.92	-49.43	-52.79
HFCs	NO	0.79	3.12	3.44	2.81	1.93	1.35	1.15	NA	NA	NA
PFCs	NO	0.01	0.00	0.00	0.00	0.00	0.00	0.00	NA	NA	NA
SF_6	0.08	0.11	0.08	0.07	0.07	0.06	0.06	0.06	-11.16	-21.61	-27.36
NF_3	NO	NO	0.00	0.00	0.00	0.00	0.01	0.01	NA	NA	NA
Total	**17.11**	**14.55**	**15.22**	**16.05**	**15.35**	**14.43**	**13.78**	**13.60**	**-6.23**	**-15.71**	**-20.52**

Current legislation in force is focusing on F-gas emissions reduction, mainly on reducing use of HFCs, which are used extensively in refrigeration and air conditioning systems. Those PaMs are reflected in current projections. Reported and projected emissions of F-gases are shown in Tab. 2-36 and overall result of F-gases projections on Fig. 2-10. Decrease of HFCs, PFCs, NF_3 emissions compared to 1990 cannot be calculated because at that time F-gases were not used in the Czech Republic and thus emissions are reported as not occurring (NO)(Tab. 2-36), the base year for F-gases is 1995 (CHMI 2018, IPCC 2006). It is expected that HFCs emissions will start to decrease around the year 2020. Compared to 2016, HFCs emissions should be 66% lower in 2040. The decrease of F-gas emissions will not be rapid as someone could expected because it is important to take into account that emissions are releasing during equipment lifetime and for some cases lifetime of equipment can be more than decade. SF_6 and NF_3 are used by semiconductor manufacturers; SF_6 is also used as insulation gas in switchgears. Emissions of SF_6 will start to decline unlike emissions of NF_3. For NF_3 is expected that emissions will increase unless new PaM will not be adopted. PFCs are not used anymore in the Czech Republic but formation of CF_4 as a by-product during etching and cleaning in semiconductor industry is taken into account and thus emissions will be still occurring.

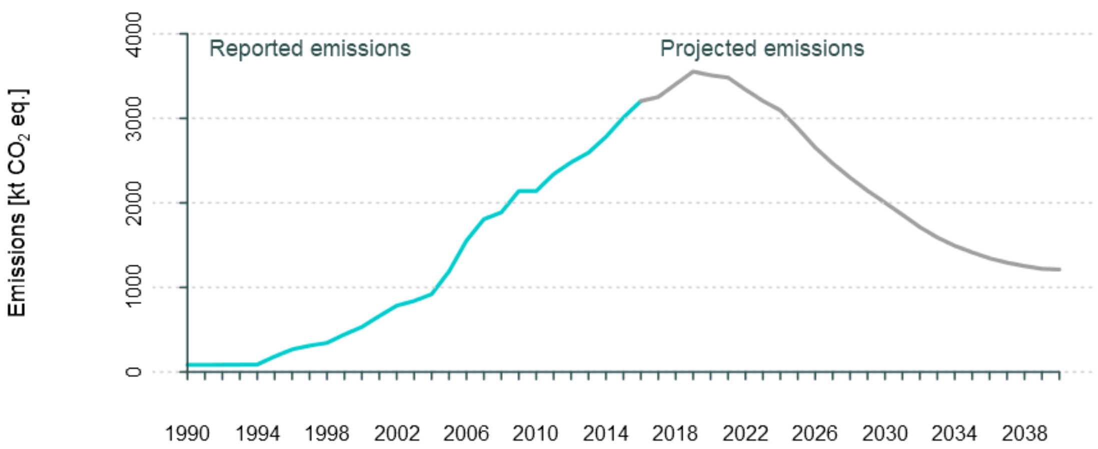


Fig. 2-10 Reported and projected F-gases (HFCs, PFCs, SF_6, NF_3) emissions from categories 2.E, 2.F, 2.G - WEM

The breakdown of reported and projected (WEM scenario) emissions by individual categories is shown in Tab. 2-37. For all categories except 2.D Non-energy use of fuels it is expected that emission will decrease compared to year 1990. Nevertheless, in the comparison with year 2016, which is the latest reporting year (CHMI 2018) it is expected that mainly emissions from 2.A Mineral Industry and 2.B Chemical Industry will increase till 2040. According to projections of activity data obtained from MIT, it is not expected that production of main products (cement, lime, glass, ammonia) is going to decrease. For main emission source subcategory 2.C.1 Iron and Steel production is expected that production and thus emissions are going to slightly decrease compared to current situation.

It is expected that F-gas emissions for category 2.E.1 Electronic Industry will increase in 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 manufacture with GDP but it should be taken into account that emissions from semiconductor manufacturing are under the threshold of significance. Main source of F-gas emissions is category 2. F Product Uses as Substitutes for ODS, mainly subcategory 2.F.1 Refrigeration and Air Conditioning. It is expected that emissions will slightly increase in coming years before all deadlines of Regulation No 517/2014 will enter into force. After that, the consumption will decrease (the use of F-gases is already banned for several applications).

Tab. 2-37 Breakdown of reported and projected emissions of GHG by categories in IPPU - WEM scenario

	Reported emissions			Projected emissions					Difference [%]		
[Mt CO_2 eq.]	1990	2005	2016	2020	2025	2030	2035	2040	1990 – 2020	1990 – 2030	1990 – 2040
2.A Mineral industry	4.08	3.35	2.82	2.90	2.96	3.02	3.09	3.15	-29.00	-25.94	-22.83
2.B Chemical industry	2.94	2.84	1.53	2.40	2.37	2.30	2.23	2.16	-18.37	-21.96	-26.69
2.C Metal industry	9.67	7.10	7.31	6.88	6.79	6.75	6.70	6.73	-28.81	-30.19	-30.41
2.D Non-energy products from fuels and solvent use	0.13	0.14	0.14	0.13	0.13	0.13	0.13	0.13	0.89	1.53	1.53
2.E Electronic industry	NO	0.01	0.01	0.01	0.01	0.02	0.02	0.03	NA	NA	NA
2.F Product uses as ODS substitutes	NO	0.80	3.12	3.44	2.81	1.93	1.35	1.15	NA	NA	NA
2.G Other product manufacture and use	0.29	0.32	0.30	0.29	0.28	0.27	0.27	0.26	-0.62	-5.92	-9.61
Total	**17.11**	**14.55**	**15.22**	**16.05**	**15.35**	**14.43**	**13.78**	**13.60**	**-6.23**	**-15.71**	**-20.52**

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

There is no additional measure for IPPU sector.

2.3.3 Sensitivity analysis

Projections of greenhouse gas emissions from IPPU sector are based on calculation sheets used for emission estimates in National Inventory Report (CHMI 2018). Activity data is only variable which changes during projected period 2017 – 2040 (please see chapter 2.3.1 for more detailed information about projections of activity data). Emission factors are constant during projected period and thus sensitivity analysis would not bring any interesting outcomes for categories under 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 emission estimates are constant during the projected period.

Only category for which could sensitivity analysis bring interesting output is category 2.F.1 Refrigeration and Air Conditioning, which is also a key category (CHMI 2018). Emission estimates and projections are prepared by using national model Phoenix, which take into account specific approach for calculating the amount of chemical remaining in the equipment at decommissioning. The amount of chemical remaining in the equipment at decommissioning is calculated by using the Gaussian distribution model with mean at the lifetime expectancy for newly filled equipment and only half lifetime expectancy is assumed for serviced equipment (Ondrusova, Krtkova 2018). Sensitivity analysis for category 2.F.1 is implemented for the WEM scenario using increased/decreased consumption of F-gases by ±5% (respecting the emission trend from National Inventory Report (CHMI 2018)). The result of the sensitivity analysis is depicted in Tab. 2-38 and Fig. 2-11.

Tab. 2-38 Sensitivity analysis using variable consumption of F-gases in category 2.F.1 under IPPU sector

Emission difference [%]	2020	2025	2030	2035	2040
WEM and WEM +5%	2.12	3.16	4.23	4.93	4.91
WEM and WEM -5%	-2.12	-3.16	-4.23	-4.93	-4.91

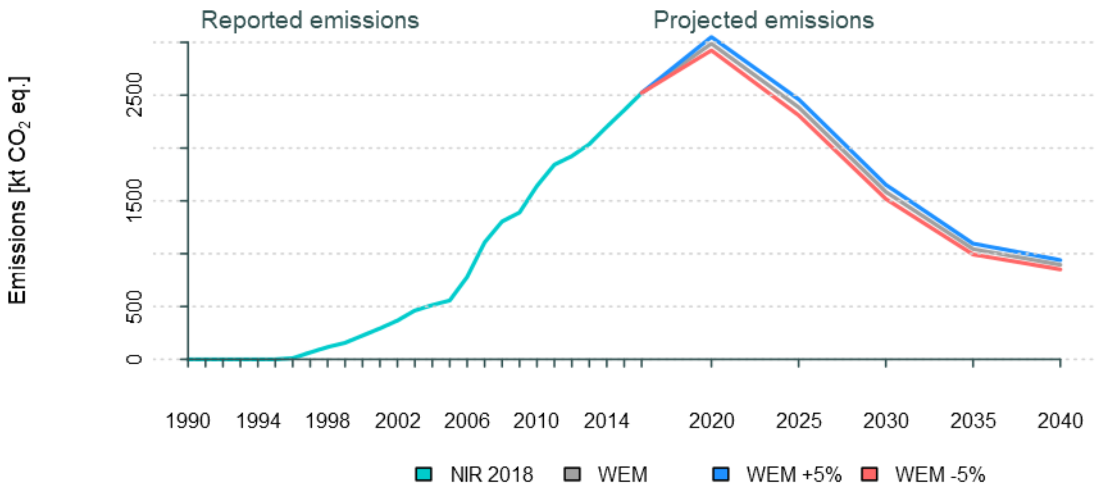


Fig. 2-11 Sensitivity analysis using variable consumption of F-gases in category 2.F.1 under IPPU sector

2.3.4 Difference between previously and currently reported projections

Unlike previous projections (CHMI 2017), current projections are based on the methodology used in the National Inventory Report (CHMI 2018) in the IPPU sector. Further, previous projections (CHMI 2017) were concerned only on activities with a major contribution to total GHG emissions, current projections take into account all source categories under IPPU. Due to major changes in the preparation of projections in IPPU, overall result of previous projections (CHMI 2017) and current projections is different. It was expected, that total emissions from IPPU should decrease more rapidly (CHMI 2017) than it is expected now. The most visible difference is for F-gases projections. The decrease of F-gases emissions should be quicker and more rapid according previous projections (CHMI 2017) than it is expected now. It should be noted, that current projections use national model Phoenix for F-gas emission estimates in 2.F.1 and the model was not introduced during preparation of previous projection (Ondrusova, Krtkova 2018, CHMI 2018).

2.4 Agriculture

In terms of greenhouse gas (GHG) emissions in the country, Agriculture is the third largest sector in the Czech Republic. In 2016, it produced 7% of total GHG emissions incl. LULUCF (7% excl. LULUCF) which is 8, 519.68 kt CO_2 eq. of that quantity, 42% originated from Managed Agricultural Soils, 34% from Enteric Fermentation and 19% from Manure Management. CO_2 emissions from liming and urea application on managed soils contribute with 4% of the total agricultural emissions in 2016. The share of emissions categories on the total emissions is almost the same in 2015 and 2016. During the period 1990 - 2016, the total emissions from Agriculture decreased by 46%. The quantitative overview and emission trends in the reported period are provided in Fig. 2-12 and Tab. 2-39 (CHMI 2018).

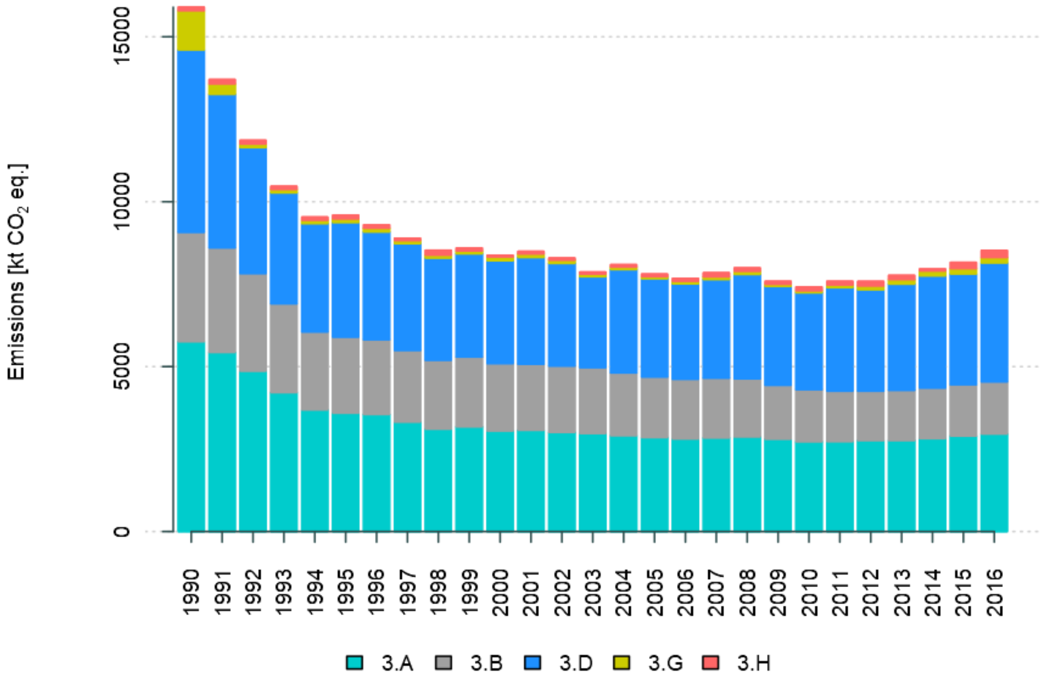


Fig. 2-12 The emission trend of agricultural sector in period 1990-2016 (CHMI 2018)

The sum of emissions from Agriculture in the Czech Republic culminated on the beginning of the reporting period (in 1990), the lowest emissions were estimated in 2010 (47% of the total emission in 1990). The reason of the relatively significant decrease after 1990 was the decreasing of population of livestock. The total emissions are relatively stable from 1997 till 2016 when they are fluctuating ±10% with the lowest level at 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. 2-39 Reported emissions in CO_2 eq. by emitted gases

[Mt CO_2 eq.]	Reported emissions						
	1990	**1995**	**2000**	**2005**	**2010**	**2015**	**2016**
CO_2	1.30	0.22	0.16	0.14	0.17	0.35	0.38
CH_4	7.45	4.77	4.08	3.79	3.48	3.62	3.70
N_2O	7.15	4.60	4.13	3.87	3.76	4.18	4.44
Total	**15.90**	**9.59**	**8.37**	**7.80**	**7.41**	**8.16**	**8.52**

Source: CHMI 2018

2.4.1 Methodological issues

The projections presented in this report are based strictly on the methodology used in the National Inventory Report (CHMI 2018) in the Agriculture sector. Trends in activity data and the emission factors used in calculation were derived from two official documents of the Ministry of Agriculture (MA 2016, MA 2018) and were discussed with experts of the agricultural policy and rural development (Budnakova 2018, Dedina 2018).

There are three important sources of data sets used for estimation:

- animal populations (number of heads per animal categories),
- amount of nitrogen from fertilizers applied to agricultural soils,
- annual harvest production.

The adapted Excel spreadsheet was used for these predictions. Projected emissions are estimated by the same processes as it is used in National Inventory Report (CHMI 2018) (Tier 2 and Tier 1 methodology).

Lack of some activity data (body weight of cattle, yield of crop within 2030 - 2040) was substituted by values derived by standard statistical approaches (regression based on historical data, long term average in case of data without regression trend etc.).

In some cases, if it is very difficult to forecast the future development (e.g. content of the fat in milk in 2030 - 2040, the amount of sewage sludge applied to soils etc.), the constant values were used in estimation.

The projected emissions in Agriculture retain the trend in the emissions reported for the 1990 - 2016 period (CHMI 2018) taking into account the current status and hypothetic developments in this sector. The trend series are consistent for both methane and nitrous oxide. For methane, the decrease in emissions for enteric fermentation and manure management since 1990 is connected with the decrease in the numbers of animals (especially cattle and swine). Since 1994, it seems that agrarian conditions have settled down to the current level. The reduction of animal 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.

2.4.1.1 Methane emissions

Enteric fermentation and manure management are the main sources of methane emissions in agriculture. Tier 2 (cattle) and Tier 1 (other animal categories) are used for emission estimation in the National Inventory Report (CHMI 2018).

Activity data, specifically animal population data, such as number of cattle, pigs and poultry, are decisive for projections, because the emission factors used are default (IPCC 2006) or their estimation is depending on numbers of heads in populations and their structure. The prediction of the number of animals for projected period is shown in the following Tab. 2-40. The sector development strategy published by the Ministry of Agriculture in 2016 (MA 2016, MA 2018) and validated by expert judgement was used for this prediction.

The cattle population rapidly declined during 1990 - 2011 (cattle by more than 60%). From 2012 the population is slowly growing (about 0.5 - 2% per year) and the similar trend is predicted for the period 2020 - 2040. The more intensive growth is predicted for pig population, specifically a rise up to 40% within 2016 - 2040, and for poultry population with growth up to 20% from 2016 to 2040. The emission coefficients used to estimate methane emissions are taken from the National Inventory Report (CHMI 2018). The methodology of emission estimation is linked to the IPCC 2006 Gl. (IPCC 2006) and the emission categories are linked to the CRF format.

Tab. 2-40 Activity data – animal population

Animal population	Reported data			Projected data				
	1990	2005	2016	2020	2025	2030	2035	2040
Cattle	3 506	1 397	1 416	1 430	1 500	1 555	1 570	1 580
Swine	4 790	2 877	1 610	1 600	1 900	2 100	2 200	2 200
Sheep	430	140	218	235	240	250	250	250
Goats	41	21	27	30	35	40	40	40
Horses	27	33	32	35	35	35	35	35
Poultry	31 981	25 372	21 314	23 780	24 180	26 695	26 695	26 695

Source: 1990, 2005 and 2016 (CzSO), 2020 -2040 (MA 2018)

2.4.1.2 Nitrous oxide emissions

Manure management and managed 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 animal waste system that is currently applied. Tier 2 (cattle) and Tier 1 (other animal categories) are used for the associated GHG estimation in the National Inventory Report (CHMI 2018).

Animal population data, mainly number of cattle, pigs and poultry, are decisive for the projection (see previous chapter). The total N_2O emissions rapidly decreased by 50% during the period 1990 - 2012, and thereafter showed an increasing trend by 0.5% per year since 2012. A similar trend is expected for the predicted period.

The total emissions from managed agricultural soils decreased by 35% 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 of the Czech Republic (Budnakova 2018). This trend is confirmed by the 2.4% decrease of amount of N applied to the soils in 2017 in comparison with the previous year. The constant amount of N applied to the soil is projected for the period 2020 - 2040.

A prognosis of the total agricultural plant production is very uncertain. Crop harvest depends on climatic factors and trading preferences. The projections are based on strategical forecast of the Ministry of Agriculture (MA 2016) on development of sowing areas for agricultural crops and also on some observed trends in demands of the Czech food consumers. 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 nitrous oxide emissions were taken from the National Inventory Report (CHMI 2018). The methodology of emission estimation corresponds to the IPCC 2006 Gl. (IPCC 2006) and the emission categories are linked to the CRF format.

Tab. 2-41 Activity data – application of mineral fertilizers

Mineral fertilizers [t N]	Reported data			Projected data				
	1990	2005	2016	2020	2025	2030	2035	2040
	418 144	206 576	292 750	280 739	280 739	280 739	280 739	280 739

Tab. 2-42 Activity data – annual harvests

Annual Harvest [kt]	Reported data			Projected data				
	1990	2005	2016	2020	2025	2030	2035	2040
Crops (cereals)	8 947	7 660	8 596	6 978	6 865	6 978	7 053	7 051
Pulses	152	96	85	70	80	93	93	94
Potatoes	1 755	1 013	700	622	662	722	724	726
Sugar beet	4 026	3 496	4 118	3 728	3 760	3 804	3 843	3 866
Fodder	7 444	3 047	3 538	3 003	2 997	3 012	3 047	3 083
Soya	2	19	28	25	29	33	38	42

2.4.1.3 Carbon oxide emissions

There are two main sources of CO_2 emissions reported in the National Inventory Report (CHMI 2018):

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 dissolve and release 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 based on the fact that the consumption of inorganic fertilizers was growing until 2016. Ministry of Agriculture (Budnakova 2018) forecast a slow decrease of its consumption in future. The predicted values (Tab. 2-43) represent a conservative estimation.

Tier 1 methods are used for estimation of CO_2 emissions from the both sources (CHMI 2018). The following table gives the reported and forecasted activity data.

Tab. 2-43 Activity data – application of limestone and urea

	Reported data [kt]			Projected data [kt]				
	1990	2005	2016	2020	2025	2030	2035	2040
Lime applied	2 676	145	379	360	360	360	360	360
Urea applied	148	101	287	279	279	279	279	279

2.4.2 Projected greenhouse gas emissions ‘With measures (WEM) scenario’ and ‘With additional measures (WAM) scenario’

The WEM scenarios include corresponding policies and measures as described in chapter 1.4. The majority of policies and measures, including objectives of conceptual strategy, originate from Strategy of Ministry of Agriculture (MA 2016, MA 2018), mentioned in the Annex 1 (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 greenhouse gases in Agriculture is expected, according to WEM scenario. The total emissions in 2040 should be approximately 7% above the total estimated in 2016 (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 (6%) 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. Specifically, the predicted growth of animal production has a strong effect on the GHG emissions in the Agriculture sector.

Tab. 2-44 Reported and projected emissions of GHG in Agriculture – WEM

[Mt CO_2 eq.]	Reported emissions			Projected emissions					Difference [%]		
	1990	2005	2016	2020	2025	2030	2035	2040	1990 – 2020	1990 – 2030	1990 – 2040
WEM	15.90	7.80	8.52	8.36	8.77	9.05	9.15	9.17	-47.41	-43.06	-42.29

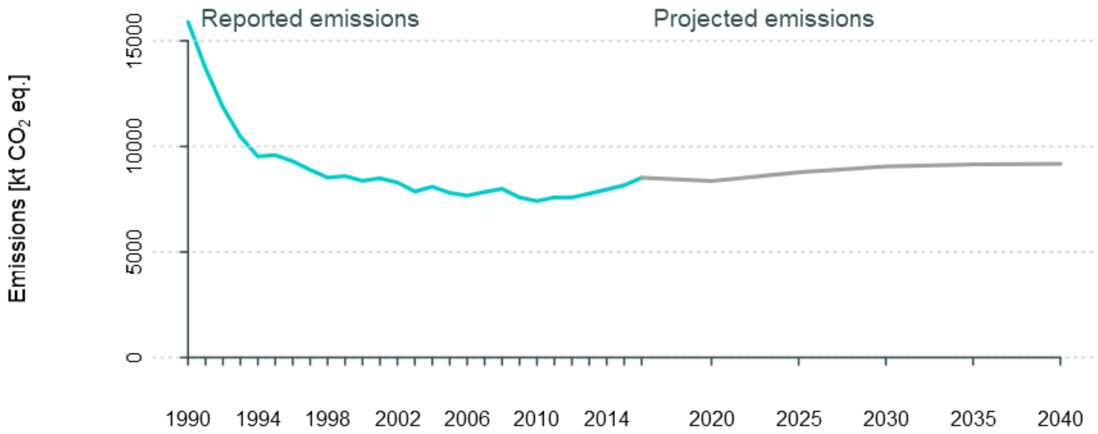


Fig. 2-13 Reported and projected emissions of GHG in Agriculture – WEM

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

WEM (with existing measures) scenario takes into account the policies and measures adopted and implemented until June 2018. The breakdown of reported and projected (WEM scenario) emissions by gases and individual categories is shown in Tab. 2-45 and Tab. 2-46.

The projections are based on the trends of the key activity data including animal population, amount of N applied to managed 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 (MA 2016) updated in 2018 (MA 2018) according the recent development in the Agriculture sector. The new forecast of the increase of animal population is less ambitious than the previous one.

Methane emissions (CH_4) coming from enteric fermentation and manure management grow from 3.70 Mt CO_2 eq. in 2016 to 4.20 Mt CO_2 eq.in 2040 due to the predicted increase of animal population. The predicted growth is estimated by about 14% in comparison with the base year.

Nitrous oxide (N_2O) emissions include emissions from manure management and from managed soils. The projected trend is slightly increasing: from 4.44 Mt CO_2 eq. in the base year to 4.61 Mt CO_2 eq. in 2040. The predicted growth is estimated by about 4% in comparison with the base year.

Prediction of CO_2 emissions is based on assumption that the consumption of nitrogen fertilizers slightly drop in comparison with the base year. The projected trend is slightly decreasing: from 0.38 Mt CO_2 eq. in the base year to 0.36 Mt CO_2 eq. in 2040. The predicted decrease is estimated by about 5% in comparison with the base year.

The total GHG emissions will increase with about 8% by the end of the projected period in comparison with the base year.

Tab. 2-45 Breakdown of reported and projected emissions of GHG by gases in agriculture - WEM scenario

	Reported emissions			Projected emissions					Difference [%]		
[Mt CO_2 eq.]	**1990**	**2005**	**2016**	**2020**	**2025**	**2030**	**2035**	**2040**	**1990 – 2020**	**1990 – 2030**	**1990 – 2040**
CO_2	1.30	0.14	0.38	0.36	0.36	0.36	0.36	0.36	-71.92	-71.92	-71.92
CH_4	7.45	3.79	3.70	3.69	3.96	4.13	4.19	4.20	-50.46	-44.61	-43.62
N_2O	7.15	3.87	4.44	4.31	4.45	4.56	4.60	4.61	-39.79	-36.21	-35.54
Total	**15.90**	**7.80**	**8.52**	**8.36**	**8.77**	**9.05**	**9.15**	**9.17**	**-47.41**	**-43.06**	**-42.29**

The trend in the emission growth is not balanced in all source categories. Emissions from manure management will grow by about 22% and those from enteric fermentation by about 11 % while emissions from the managed agricultural soils remain constant. The emissions from liming and urea application will decrease by about 5% and 3%, respectively.

Tab. 2-46 Breakdown of the reported and projected emissions of GHG by categories in agriculture - WEM scenario

	Reported emissions			Projected emissions					Difference [%]		
[Mt CO_2 eq.]	**1990**	**2005**	**2016**	**2020**	**2025**	**2030**	**2035**	**2040**	**1990 – 2020**	**1990 – 2030**	**1990 – 2040**
3.A Enteric fermentation	5.75	2.85	2.96	2.94	3.12	3.24	3.28	3.29	-49.00	-43.70	-42.82
3.B Manure management	3.32	1.84	1.58	1.62	1.78	1.88	1.92	1.92	-51.00	-43.18	-41.95
3.D Agricultural soils	5.53	2.98	3.60	3.44	3.51	3.56	3.59	3.60	-37.87	-35.56	-35.01
3.G Liming	1.19	0.06	0.17	0.16	0.16	0.16	0.16	0.16	-86.55	-86.55	-86.55
3.H Urea application	0.11	0.07	0.21	0.20	0.20	0.20	0.20	0.20	88.23	88.23	88.23
Total	**15.90**	**7.80**	**8.52**	**8.36**	**8.77**	**9.05**	**9.15**	**9.17**	**-47.41**	**-43.06**	**-42.29**

2.4.2.2 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.

2.4.3 Sensitivity analysis

Projections of greenhouse gas emissions from Agriculture sector are based on calculation sheets used for emission estimates in National Inventory Report (CHMI 2018). Activity data is only variable which changes during 2017 – 2040 (please see chapter 2.3.1 for more detailed information about projections of activity data). Emission factors are constant during 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 emission factors used for emission estimates are constant during the projected period.

2.4.4 Difference between previously and currently reported projections

The current projection estimates are lower than those of the earlier projections. The less ambition forecast of animal population growth produces a lower level of GHG emissions in the projected period Tab. 2-47. The increase of emission level between year 2005 and 2030 was +19% for earlier projections (CHMI 2017) and +16% for the current projections.

Tab. 2-47 The comparison of projected value of GHG emissions in projections estimated in 2017 (CHMI 2017) and the recent projection (2019)

[Mt CO_2 eq.]	2014	2015	2016	2020	2025	2030	2035	2040
WEM 2017	8.29	8.36		8.64	9.12	9.68	9.90	
WAM 2017	8.29	8.36		8.47	8.85	9.30	9.40	
WEM 2019			8.52	8.36	8.77	9.05	9.15	9.17

2.5 Land Use, Land-Use Change and Forestry

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 LULUCF sector, despite voluminous methodological advice compiled specifically for this sector by IPCC (IPCC 2003, IPCC 2006, IPCC 2014a and IPCC 2014b.) Therefore, the estimates related to the LULUCF sector are commonly accompanied by the largest uncertainty, commonly in range of tens of percent and larger.

The estimated emissions by individual LULUCF sub-categories for the period 1990 to 2016 are shown in Fig. 2-14 below. The emissions are expressed in units of CO_2 eq., including CO_2, CH_4 and N_2O. The dominant greenhouse gas in the 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. 2-14, but can be found in the National Inventory Report (CHMI 2018).

As apparent from Fig. 2-14, the emission quantities are largely determined by carbon stock changes in Forest land (4.A), followed by contribution of Harvested wood products (HWP) (4.G), whereas the contribution of other categories is minor.

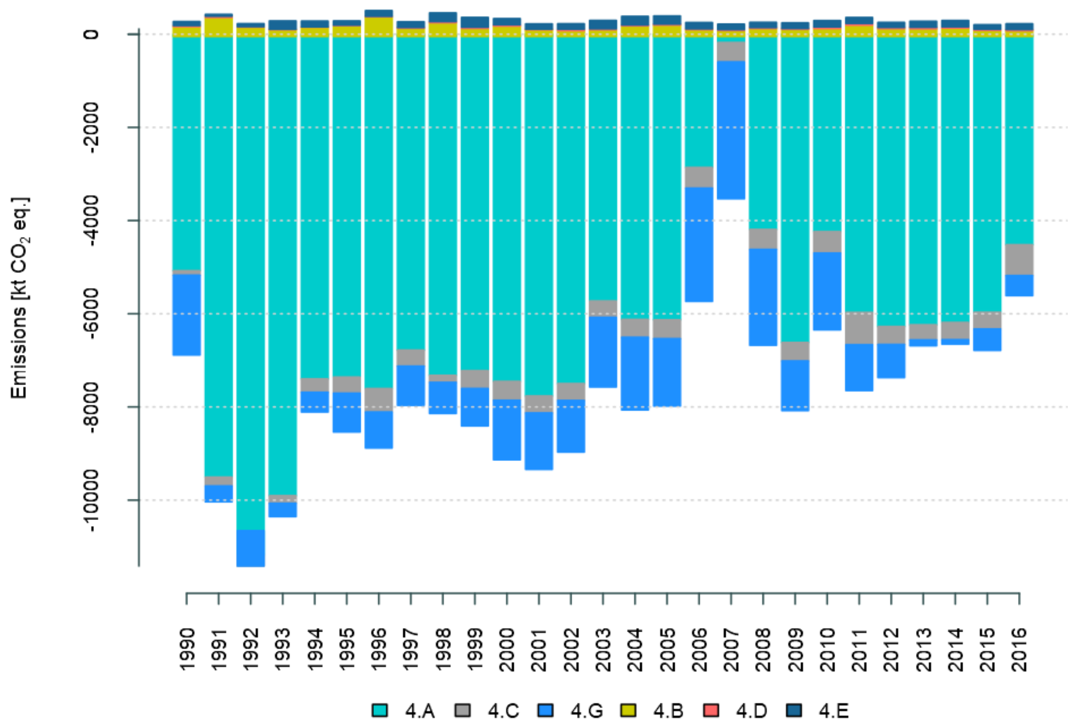


Fig. 2-14 The emission trend in LULUCF sector during reporting period 1990 - 2016 (CHMI 2018)

2.5.1 Methodological issues

There are two fundamental methodological steps of emission estimates in the LULUCF sector, which must accordingly be considered in designing projections. These steps include a) treatment of land use areas b) emission estimates for individual land-use categories c) including HWP contribution. These steps are described below and summarized in Tab. 2-50.

a) Treatment of land use areas

The emission estimates in the LULUCF sector are to a large degree determined by development of land areas categorized by their use. Therefore, the 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 2018) 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 LULUCF emission inventory use annually updated COSMC data, elaborated at the level of about 13 thousand individual cadastral units. The observed development of the major IPCC land use categories (IPCC 2006) is reported in National Inventory Report (CHMI 2018).

The projections beyond 2016 are based on the observed trends and anticipation of gradually diminishing category-specific land use changes until 2040. Specifically, for land use categories Forest land and Grassland, a half-declining trend with respect to the changes since 1990 is foreseen for the period until 2040. For Wetlands and 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 (Forest land, Settlement), parabolic function (Grassland), or linear fit (Wetlands). For 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. 2-48 and Fig. 2-15 below. There is an increase of land use categories Forest land, Grassland, Wetlands and Settlements. The area of Cropland is expected to further decrease. The changes in cropland land use category is in both relative and absolute numbers the most significant shift in land use expected in the country for the period since 2016 until 2040, the end year of the projection period. During that time, the area share of cropland would decrease from 40.6% to 39.0% in the country (Fig. 2-16), which means a loss of 127 kha in this 25-year period.

Tab. 2-48 Land use areas (kha): reported until 2016, projected until 2040 (*areas of Other land are included within Settlements)

	Reported area [kha]						Projected area [kha]				
Land use category	**1990**	**2000**	**2005**	**2010**	**2015**	**2016**	**2020**	**2025**	**2030**	**2035**	**2040**
Forest land	2629	2637	2647	2657	2668	2670	2676	2681	2684	2685	2686
Cropland	3455	3319	3286	3248	3211	3205	3153	3125	3105	3090	3078
Grassland	833	961	974	986	1001	1003	1034	1049	1061	1072	1081
Wetlands	158	159	161	163	165	166	166	168	170	171	173
Settlements	812	810	819	833	841	843	857	865	868	869	869
Other land*	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE

Source: CHMI 2018, IFER

Fig. 2-15 Actual areas of the major IPCC land use categories in the Czech Republic for the period 1990 to 2016 and the projected trends shown for the period until 2040. Within each category, a note on extrapolation approach is provided.

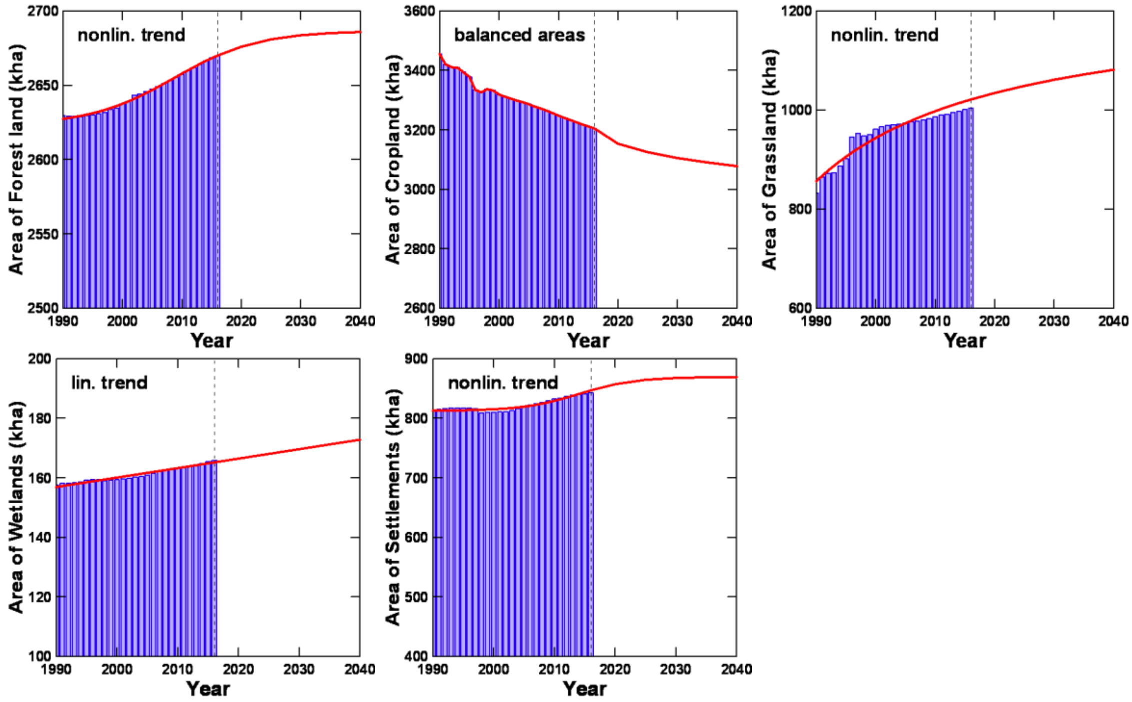
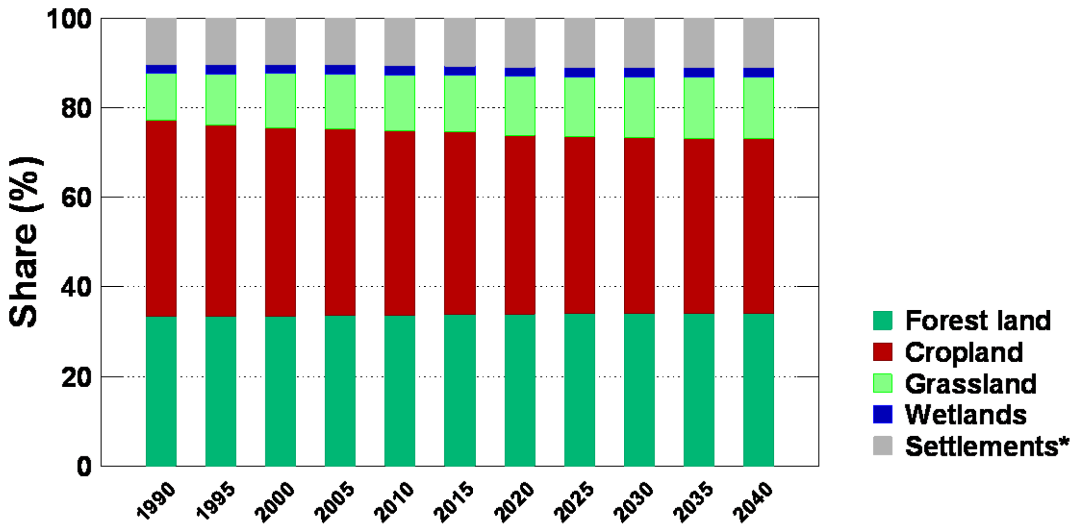


*Fig. 2-16 Share of areas for the six IPCC land use categories (*Settlements also include a fraction representing an area of Other land) in 5-year intervals since 1990 to 2040, using the actual data until 2016 (until year 2015 in the graph) and projections until 2040.*



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. The specific attention is given to forest land, which always represents the key emission category of the LULUCF sector as well as within the entire National Inventory Report (CHMI 2018). For this reason, the projections related to forestry are elaborated on the basis of the scenario modelling using EFISCEN – the European Forest Information Scenario Model (Sallnas 1990, Pussinen et al. 2001, Schelhaas 2007, Verkerk et al. 2017).

EFISCEN is a large-scale model that assesses the supply of wood and biomass from forests and projects forest resource development on regional to European scale, based on forest inventory data.

EFISCEN provides projections on basic forest inventory data (stem wood volume, increment, age-structure), as well as carbon in forest biomass and soil. EFISCEN is one of the most commonly used models applied for various tasks associated with forest resource projections in European conditions.

Specifically in the Czech Republic, EFISCEN was used earlier to analyse i) forest development under various management scenarios in selected European countries (Schelhaas et al. 2004) ii) carbon stock development until 2060 (Cienciala et al. 2008), or recently iii) climate-smart forestry and mitigation impacts (Nabuurs et al. 2018). Perhaps most importantly in the context of emission inventories under UNFCCC and KP, EFISCEN was used to construct Forest Management Reference Levels (FMRL)) for over 15 European countries under a coordinated effort of Joint Research Centre, Ispra, Italy.

The current EFISCEN projection of carbon balance on Forest Land is based on the study performed within the project CzechForScen (Contribution of forestry to the emission balance of the Czech Republic and model prediction of forest management scenarios in the conditions of the Czech Republic), funded by the Czech Ministry of Education, Youth and Sports (Cienciala 2012). The calibration data used were obtained from the database of forest management plans administered by the Forest Management Institute, Brandys n. L. They corresponded to the state of the Czech forests as of 2010. Since the model used, i.e., EFISCEN, ver. 4.2.0 (Verkerk et al. 2017), works with a time step of 5 years, the calibration data were considered fully applicable for the projections required here. The model was applied on matrices at the level of 27 specific management units, 17 age classes and aggregation of five major tree species used in the Czech Forestry. The model predictions were constrained by the actual recommendations of the Czech Forestry Act as for the regeneration period, thinning and felling that were accordingly implemented on the level of individual management groups.

The felling level request was adopted in the model identically across model scenarios. It was constructed as follows: an average felling volume for the 5-year period 2011 - 2015 for the reference year 2015, and an average felling volume for the last two known years 2016 - 2017 for the reference year 2020. Thereon, an average felling volume for the last 10 years with known harvest (2008 - 2017) was used for the remaining simulation period until 2040. The harvest included the share of so called unregistered felling volumes, which represent the harvest residues extracted in individual years as reported by the Czech Statistical Office and/or estimated by IFER – Institute of Forest ecosystem research. A constant volume share 30% was adopted for thinning operations, taking into account the relative high share of sanitary felling. This way constructed harvest demand, i.e., mean annual total felling (thinning and final cut), is summarized in Tab. 2-49.

Tab. 2-49 Harvest volumes used to drive EFISCEN model runs (identically for both WEM and WAM scenarios) for particular model time periods. All numeric values are given in Mm^3 wood volume per year.

Period	Logs	Residues	Total removals
2015	15.48	1.84	17.32
2020	18.50	2.00	20.50
2025 - 2040	16.28	1.80	18.08

Other details of this EFISCEN model implementation are described in (Cienciala 2012). The EFISCEN model projections were used for the predictions beyond 2016 until 2040 (Tab. 2-50).

The projections of greenhouse gas emissions related to other land use categories besides Forest land 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 harvested wood products (HWP), which are newly reported under UNFCCC and Kyoto Protocol since the 2015 annual national inventory submission.

Finally, the contribution of HWP was projected using the harvest activity data as reported in National Inventory Report (CHMI 2018). For the period since 2016 to 2040, harvest volumes (logs) as adopted for the EFISCEN-assisted estimates, were used as input and proxy for estimation of HWP contribution following the identical methodology for HWP as described in National Inventory Report (CHMI 2018).

Tab. 2-50 Summary of the methodological approaches used for the LULUCF categories

Activity data (AD) and category	Approaches
Land use areas for individual land use categories	COSMC data for 1990 - 2016, thereon projections until 2040 using - linear trend (Wetlands), sustained rate - non-linear/sigmoidal trend (Settlements), sustained rate - non-linear/sigmoidal trend (Forest land, Cropland, Grassland), half-reduced trend relative to 1990 - 2015
Emission estimates for Forest land	National Inventory Report data for 1990 - 2016 (CHMI 2018), thereon projections using EFISCEN model version 4.2.0 (Verkerk et al. 2017)
Emission estimates for other land use categories except Forest land	National Inventory Report data for 1990 - 2016 (CHMI 2018), thereon a rescaled reference data as of 2015 using land area as a proxy
HWP contribution	National Inventory Report data for 1990 - 2016 (CHMI 2018), thereon estimates until 2040 using harvest demand (logs) as applied for the EFISCEN-assisted projections, identically for WEM and WAM scenarios

2.5.1.1 Definition of WEM and WAM scenarios

Definition of scenario WEM: The WEM (With Existing Measures) scenario includes the development of land areas of individual land use categories as shown in Tab. 2-48 and Fig. 2-15. 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 (2016) for the individual land use categories with exception of CO_2 emissions from Forest Land and HPW emission contribution (Tab. 2-50).

For Forest Land, the EFISCEN model ver. 4.2.0 (Verkerk et al. 2017) scenario is used that includes the currently implemented forest management recommendations (age-specific thinning and felling per forest types) of the Czech Forestry Act and actual species composition as of the reference year. The felling request remains stable and as of today (17.29 mil. m^3/year) for the entire projection period with exception of year 2015 with its already reported and available felling quantity. The species composition of the stands does not change in WEM scenario, and remains identical as of 2012, reflecting the source of calibration data to EFISCEN (Verkerk et al. 2017).

For HWP contribution, the input activity data on harvest volumes (logs) as adopted for the EFISCEN-assisted estimates were used as input and proxy across the entire projected period until year 2040.

Definition of scenario WAM: The WAM (With Additional Measures) scenario is similar to WEM. However, it differs in the applied EFISCEN model scenario for Forest Land and CO_2 emissions, the key category of the LULUCF emission inventory. Specifically, it 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, applicable to period beyond 2016. The proposed species change is driven by the actual management groups and by altitude of their locations. The details of this management scenario correspond to SSC2 scenario as described in the background study of Cienciala (Cienciala 2012a) and also recently used in a study on carbon-smart forestry (Nabuurs et al. 2018). This is the essence of the recommendations of the elaborated 2nd National Forest Program (Key Action 6) (Cienciala 2012a).

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

The historical data and projections using the WEM and WAM scenarios are shown in Tab. 2-51 and Fig. 2-18. It can be observed that for the nearest decades, the LULUCF sector is projected significantly loose its emission sink strength. This is largely due to the development on Forest land under the assumed harvest demand for both WEM and WAM scenario. The difference between the WEM and WAM scenarios is notable and requires a careful interpretation with respect to the current (as of 2018) and coming trends in the Czech forests and forestry, as well as understanding the effects of the proposed adaptation measures.

The essence of the presented trends and differences in WEM and WAM 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 fellings (http://www.silvarium.cz/lesnictvi/rozsah-kurovcove-kalamity-predstavuje-vysoke-riziko-pro-rok-2019).
- Even though the planned felling is restricted to minimum, the rising share of sanitary logging is very likely to result in overall record-high felling volumes. This trend is partly reflected in the adopted (for both WEM and WAM) increased harvest levels for the five-year period until 2020, expected to decrease again by 2025 to the previous historical levels. The effect of this is increased emissions, making the entire LULUCF sector even turning to a source of emissions in 2020.
- The emissions in 2025 - 2040 reflect changes in age structure (WEM) as well as species composition (WAM). Both scenarios make the LULUCF sector a much weaker sink as compared to the historical period.
- The quantitative difference between WEM and WAM observed for the period until 2040 is explained by the fact, that WAM projects an increasing share of more resilient, but less productive broadleaved species (oak, beech and others). On the contrary, WEM scenario hypothetically retains the current spruce representation, which might be more productive under the optimistic conditions of stabilized health state (suppressed bark beetle outbreak and other disturbances).
- WAM “adaptation” scenario is the preferred scenario, which in long term (exceeding the horizon of 2040) will result in 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. 2-17).
- The issue of production “security” is not factored in WEM scenario, as this is a highly uncertain factor. If considered, this would include a higher frequency of undesired disturbances to unstable spruce-dominated forest stands, which would be reflected in higher sanitary fellings and hence also emissions.
- The overall importance of wood harvest volume drain on emission balance in LULUCF sector is demonstrated with sensitivity analysis using changed harvest levels (Fig. 2-20). Evidently, any disturbance to forests leading to elevated harvest volume levels will negatively affect carbon balance in the sector.
- Note that the WEM and WAM scenarios as defined here should be considered as conservative (i.e., optimistic) in term of forest health. Currently (as of September 2018), new information on forests status suggests an increasing probability of a more pessimistic development of spruce and pine dieback in the country.

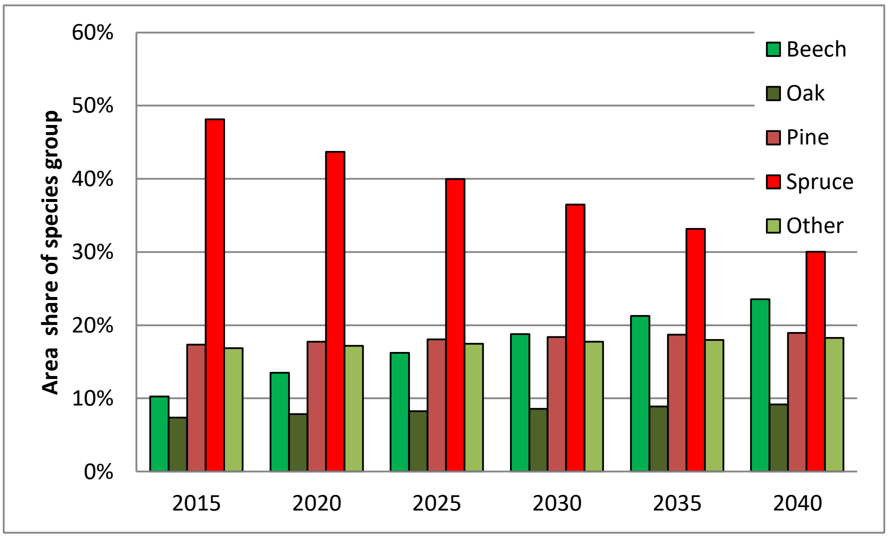
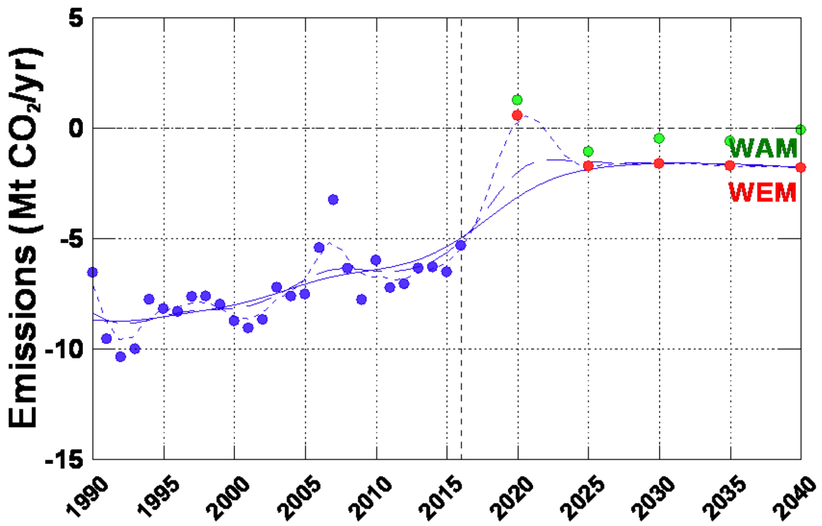


Fig. 2-17 Historical (2015) and projected (2020 - 2040) tree species change by EFISCEN within the WAM scenario, expressed by share on forest area by individual species groups.

Tab. 2-51 Reported and projected emissions of GHG in LULUCF sector – WEM and WAM

	Reported emissions			Projected emissions					Difference [%]		
[Mt CO_2 eq.]	1990	2005	2016	2020	2025	2030	2035	2040	1990 – 2020	1990 – 2030	1990 – 2040
WEM	-6.56	-7.54	-5.34	0.55	-1.74	-1.63	-1.73	-1.81	-108.44	-75.22	-72.41
WAM	-6.56	-7.54	-5.34	1.25	-1.09	-0.49	-0.61	-0.10	-118.97	-92.51	-98.46

Fig. 2-18 Reported and projected emissions of GHG in LULUCF sector for WEM (red) and WAM (green) scenarios, respectively. The historical data (blue) and the WEM scenarios are accompanied by a least square smooth lines using different tension values that determine the local flex.



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

The breakdown of historical and projected (WEM scenario) emissions by gases and individual land use categories is shown in Tab. 2-52 and Tab. 2-53, including the individual LULUCF categories. The emissions in the LULUCF sector are mostly determined by carbon stock changes in the category 4.A Forest Land and partly by the newly reported contribution of HWP. For the interpretation of the estimated emission levels trends in 4.A under WEM, see the lead text in chapter 2.5.2

Tab. 2-52 Breakdown of reported and projected emissions of GHG by gases in LULUCF sector - WEM scenario

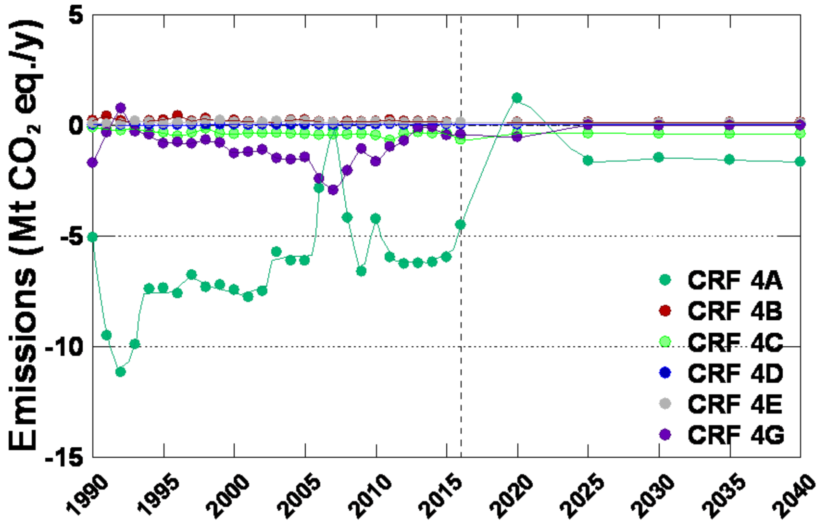
[Mt CO_2 eq.]	Reported emissions			Projected emissions					Difference [%]		
	1990	2005	2016	2020	2025	2030	2035	2040	1990 – 2020	1990 – 2030	1990 – 2040
CO_2	-6.65	-7.63	-5.40	0.50	-1.80	-1.68	-1.79	-1.87	-107.46	-74.67	-71.90
CH_4	0.04	0.05	0.03	0.03	0.03	0.03	0.03	0.03	-28.07	-27.85	-27.79
N_2O	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.03	-35.45	-35.48	-35.54
Total	**-6.56**	**-7.54**	**-5.34**	**0.55**	**-1.74**	**-1.63**	**-1.73**	**-1.81**	**-108.44**	**-75.22**	**-72.41**

Tab. 2-53 Breakdown of reported and projected emissions of GHG by categories in LULUCF sector - WEM scenario

[Mt CO_2 eq.]	Reported emissions			Projected emissions					Difference [%]		
	1990	2005	2016	2020	2025	2030	2035	2040	1990 – 2020	1990 – 2030	1990 – 2040
4.A Forest Land	-5.08	-6.13	-4.52	1.21	-1.62	-1.48	-1.57	-1.66	-123.91	-70.92	-67.36
4.B Cropland	0.21	0.24	0.12	0.13	0.13	0.13	0.13	0.13	-39.26	-40.21	-40.75
4.C Grassland	-0.10	-0.40	-0.66	-0.37	-0.38	-0.38	-0.38	-0.39	282.70	292.78	300.46
4.D Wetlands	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	17.46	19.70	21.95
4.E Settlements	0.09	0.18	0.12	0.10	0.10	0.10	0.10	0.10	13.11	14.51	14.71
4.G HWP	-1.71	-1.45	-0.43	-0.54	0.00	-0.02	-0.02	-0.02	-68.39	-98.72	-98.98
Total	**-6.56**	**-7.54**	**-5.34**	**0.55**	**-1.74**	**-1.63**	**-1.73**	**-1.81**	**-108.44**	**-75.22**	**-72.41**

The quantitative share and trends of emissions under WEM scenario by individual LULUCF categories shows Fig. 2-19. Prominently, the category 4.A Forest land dominates in historical period until 2016. It is expected to cease for the next years and decades to come due to the reason explained in chapter 2.5.2.

Fig. 2-19 Breakdown of historic and projected (WEM scenario) emissions of GHG by land-use categories within 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).



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

The WAM scenario includes the proposed change of dominantly spruce even-aged forests stand to more diverse stands with a notably higher share of broadleaved tree species such as beech and oak, applicable to period until 2040. The proposed species change is driven by the actual management groups and by altitude of their locations. Although the net positive effect of WAM scenario is negative for the projected period until 2040, it should warrant additional important benefits. Specifically, the WAM scenario should result in more resilient and stable forest stands, which is essential for long-term sustainability of forest production and entire spectrum of important services that forests provide.

Tab. 2-54 and Tab. 2-55 provide numeric information on reported and projected emissions by individual gases and LULUCF categories for WAM scenario. The overall interpretation of these numbers is basically identical as given for the data under WEM scenario in chapter 2.5.2.1

Tab. 2-54 Breakdown of reported and projected emissions of GHG by gases in LULUCF sector - WAM scenario

	Reported emissions			Projected emissions					Difference [%]		
[Mt CO_2 eq.]	**1990**	**2005**	**2016**	**2020**	**2025**	**2030**	**2035**	**2040**	**1990 – 2020**	**1990 – 2030**	**1990 – 2040**
CO_2	-6.65	-7.63	-5.40	1.19	-1.15	-0.55	-0.67	-0.16	-117.86	-91.74	-97.61
CH_4	0.04	0.05	0.03	0.03	0.03	0.03	0.03	0.03	-28.07	-27.85	-27.79
N_2O	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.03	-35.45	-35.48	-35.54
Total	**-6.56**	**-7.54**	**-5.34**	**1.25**	**-1.09**	**-0.49**	**-0.61**	**-0.10**	**-118.97**	**-92.51**	**-98.46**

Tab. 2-55 Breakdown of reported and projected emissions of GHG by categories in LULUCF sector - WAM scenario

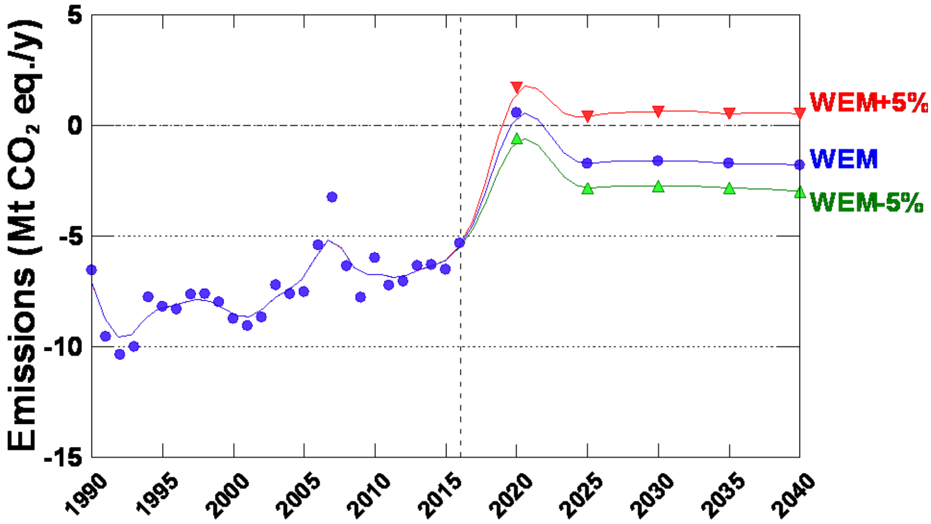
	Reported emissions			Projected emissions					Difference [%]		
[Mt CO_2 eq.]	**1990**	**2005**	**2016**	**2020**	**2025**	**2030**	**2035**	**2040**	**1990 – 2020**	**1990 – 2030**	**1990 – 2040**
4.A Forest Land	-5.08	-6.13	-4.52	1.90	-0.96	-0.34	-0.46	0.05	-137.53	-93.28	-101.04
4.B Cropland	0.21	0.24	0.12	0.13	0.13	0.13	0.13	0.13	-39.26	-40.21	-40.75
4.C Grassland	-0.10	-0.40	-0.66	-0.37	-0.38	-0.38	-0.38	-0.39	282.70	292.78	300.46
4.D Wetlands	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	17.46	19.70	21.95
4.E Settlements	0.09	0.18	0.12	0.10	0.10	0.10	0.10	0.10	13.11	14.51	14.71
4.G HWP	-1.71	-1.45	-0.43	-0.54	0.00	-0.02	-0.02	-0.02	-68.39	-98.72	-98.98
Total	**-6.56**	**-7.54**	**-5.34**	**1.25**	**-1.09**	**-0.49**	**-0.61**	**-0.10**	**-118.97**	**-92.51**	**-98.46**

2.5.3 Sensitivity analysis

Sensitivity analysis is solely based on analysing the category 4.A Forest land. This is the key category of the Czech emission inventory, determined by biomass carbon stock changes in the emission sub-category 4.A.1 Land remaining Forest Land. This 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 to be 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 5% with respect to the selected baseline (harvest as in WEM/WAM scenarios) using the EFISCEN model. The model outcome as implemented for the WEM scenario and its two variants is shown in Fig. 2-20. It is apparent that a relatively small change in harvest demand would indeed have a significant effect on emissions from the LULUCF sector. Harvest removals smaller than 5% relative to WEM would result in a continuous carbon sink in forestry. Contrarily, increased harvest removals by 5% relative to WEM would already change the LULUCF sector from sink into a source category for the projected period until 2040. It should also be noted that harvest demand is a more powerful short-term factor affecting emissions as compared to gradual tree species change that distinguish WEM and WAM scenarios and affect carbon balance more on long-term basis at a country-level scale.

Fig. 2-20 Sensitivity analysis using variable harvest demand and its effect on emissions in LULUCF under WEM scenario



2.5.4 Difference between previously and currently reported projections

There has been no fundamental methodological difference in the concept of the LULUCF projections apart from treating the projections for the category 4.A Forest land and related aspects of the WEM and WAM scenarios.

Specifically, the harvest demand that dominantly drives carbon budget on Forest land has been altered based on new available information from the Czech Statistical Office and elsewhere. In contract to the constant harvest level of 17.29 Mm^3/year adopted for earlier projection estimates, the current harvest scenario (identical for WEM and WAM) were defined more truly following the available updated information (see Tab. 2-48). More specific information and justification of the adopted (generally somewhat higher) harvest data and assumptions are given in chapter 2.5.1.

2.6 Waste

Waste sector in the Czech Republic can be separated to 4 distinctive source categories. First, so far dominant category is 5.A – Solid waste disposal. This category is source of CH_4 emissions. Emissions of CO_2 from this category are of a biogenic origin and are not included to the projected emissions. Second source category is a category 5.B – Biological treatment of waste. This source category consists of composting and anaerobic digestion of waste. 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 Czech Republic. Emissions from use of biogas produced in anaerobic digestion are not part of this source category as it should be accounted in 1.A – Energy however leakage emissions from digestion process are accounted. Third source category is 5.C – Waste incineration. When waste incineration produces useable energy its emissions are accounted in energy sector. Only hazardous and industrial waste incineration is accounted in 5.C, which is the same approach as in the National Inventory Report (CHMI 2018). Waste incineration produces all three major greenhouse gasses, but predominantly it's a fossil CO_2 source. Last category is 5.D – Wastewater treatment. This category 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 2016, the total aggregate GHG emissions from Waste were 5, 561.26 kt CO2 eq., which represent increase of 78% compared to 1990. GHG emissions trend from the Waste sector is depicted on Fig. 2-21 (CHMI 2018).

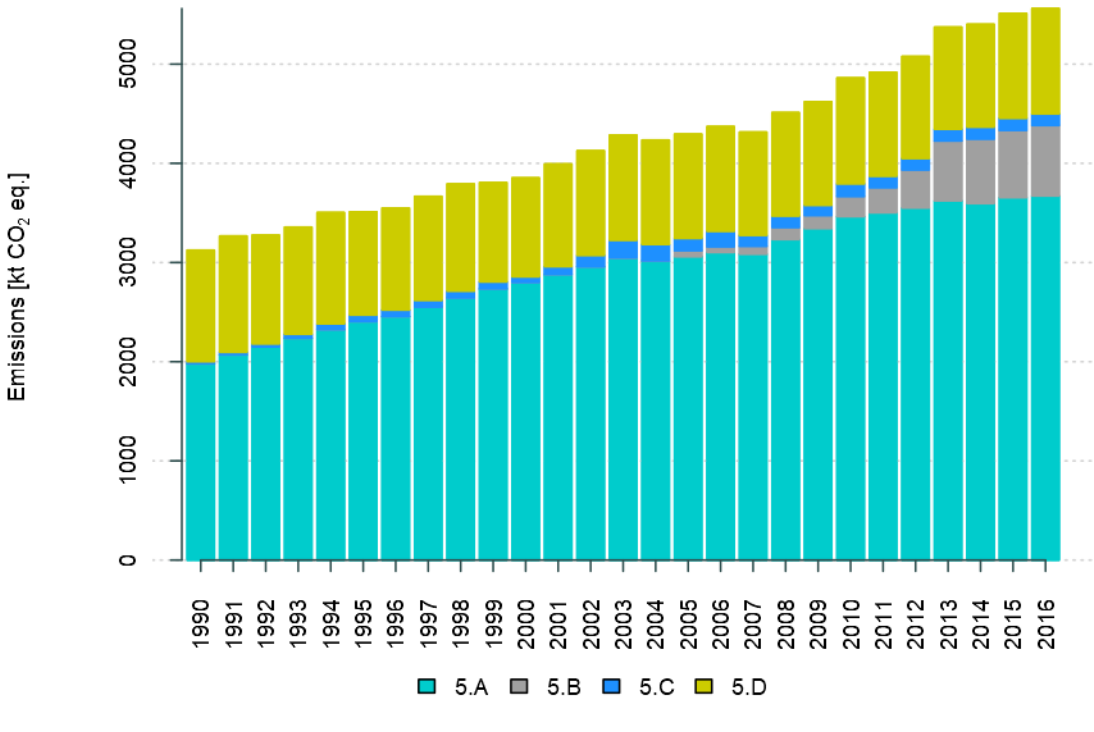


Fig. 2-21 The emission trend in Waste sector during reporting period 1990 - 2016

Overall development of the waste sector in past decades is dominated by landfilling (Solid Waste Disposal Sites - SWDS) of waste. Landfilling is still dominant type of waste management nowadays, but its importance is decreasing due to rise of waste recycling; collection of separated waste parts, composting and energy recovery. In not so far future landfilling, mainly landfilling of municipal and organic waste might disappear as the capacity of landfills is decreasing and other options are preferred by national legislation and by obligations of the Circular Economy Package (EC 2018).

Waste sector has high uncertainty in regards of 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. Waste sector is ultimate end point of all consumption and economic activity therefore it is also highly dependent of whole economy setting, which makes it even harder to predict as well. Default uncertainty for the GHG emission levels in waste sector are around +/-40%, with some source subcategories reaching to factor of 2. 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 2018).

2.6.1 Methodological issues

The projections of greenhouse gas emissions in waste sector are based on data and methodology used for emission estimates reported in National Inventory Report (NIR) (CHMI 2018). Activity data reported in NIR (CHMI 2018) are obtained from database VISOH ("Veřejné informace o produkci a nakládání s odpady") which contains information about production and management of waste in the Czech Republic. The spreadsheets used for the NIR (CHMI 2018) have been adapted for the all sectors except 5.D – Wastewater treatment and discharge which has timelines for CH_4 and N_2O emissions extended straight from the recent year emission values.

Emissions estimated up to year 2024 are based on assumptions and forecasted scenario in the Waste Management Plan 2014 (WMP) (MoE 2014). Timeline has been prolonged up to 2040 by building upon the scenarios in WMP (MoE 2014) and by the new obligations of the Circular Economy Package (EC 2018).

For the category 5.A – Solid waste disposal, assumptions and landfilling data from WMP (MoE 2014) have to be explained first, in order to show transparently the steps how the category 5.A – Solid waste disposal emission estimates are obtained. The key assumption in WMP (MoE 2014) for the future greenhouse gas (GHG) emissions development is the following: "The developed forecasts of municipal waste (MW) production imply that municipal waste production between 2013 and 2024 will decline slightly (MoE 2014)." The assumptions for the waste management options are that due to the diversion of materially recoverable components of mixed municipal waste (MMW) in the years 2013 - 2024 a decrease in landfilling occurs, compensated by a significant increase in material recovery of MW, by the development of composting and anaerobic digestion, and last but not least, by energy recovery (see Tab. 2-56 and Tab. 2-57). The estimated landfilling volumes reflect the assumptions. Approximately linearly decreasing volume of landfilled MW is acquired by calculating waste management types to fit into the total production of MW in a way ensuring compliance with specified requirements to restrict landfilling of biodegradable municipal waste and materially recoverable MW stipulated in the WMP (MoE 2014). The trend of reduced landfilling thus corresponds to the expected ban or one of the variants of a significant reduction in landfilling of untreated waste (i.e. more or less waste of group 20, because the products of waste treatment are reported in group 19 and inert waste (soil etc. represents in group 20 a marginal item) in the period after 2025 (MoE 2014). Secondly, for the category 5.A – Solid waste disposal the projected GHG emissions were calculated using the IPCC Spreadsheet for Estimating Methane Emissions from Solid Waste Disposal Sites by applying the projected landfill values into it (CHMI 2018). The WMP (MoE 2014) landfill values have been adjusted by inclusion of industrial correction factor 0.26 Mt to keep the forecast in line with the CRF values. Default emission factors from IPCC 2006 Gl. (IPCC 2006) were applied (CHMI 2018). Finally, a ten year average of recovered landfill gas (LFG) was applied to the spreadsheet to get values for 'With additional measures (WAM) scenario' for 2017 - 2029. From 2030 the WAM scenario is connected to the previous submission's WAM curve, which reflects the increased recovery of LFG until 2040. 'With existing measures (WEM) scenario' is extrapolated from a year 2030 to 2040. WEM scenario has less recovered LFG than WAM from the year 2025 onwards. Recovered methane from LFG is used for energy purposes and subtracted from total emissions

(CHMI 2018). The projected trend of emissions from category 5.A is decreasing steeply (see Tab. 2-61).

The category 5.B – Biological treatment of solid waste consists of a category 5.B.1 – Composting and a category 5.B.2 – Anaerobic Digestion at Biogas Facilities. The category 5.B.1 – Composting includes subcategories 5.B.1.a – Municipal solid waste (MSW) and 5.B.1.b – Other waste (CHMI 2018). 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. Updated WMP waste values were applied to the spreadsheet until 2024 and the time line has been extrapolated until 2040. For the sub category 5.B.2 – Anaerobic Digestion at Biogas Facilities an average 5% leakage from years 2013 - 2016 was included as a constant to the forecast. The leakage amounted to 0.6 Mt CO_2 eq. The projected trend of emissions from category 5.B is increasing.

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 2018). Incinerated H/IW has been extrapolated until 2040 and the results were inserted into the spreadsheet to get emission forecast for CO_2, CH_4 and N_2O until 2040. 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.

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 have been extrapolated until 2040. The projected trend of emissions from 5.D is stagnant.

Tab. 2-56 Forecast of total MMW production by all subjects in the Czech Republic (MoE 2014)

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Municipalities	2.22	2.30	2.20	2.18	2.16	2.15	2.13	2.12	2.10	2.09	2.07	2.05
Nonmunicipal entities	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Total	**3.12**	**3.20**	**3.10**	**3.08**	**3.06**	**3.05**	**3.03**	**3.02**	**3.00**	**2.99**	**2.97**	**2.95**

Tab. 2-57 Forecast of municipal waste management (MoE 2014)

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Material recovery	1.56	1.85	1.88	2.14	2.05	2.08	2.12	2.16	2.21	2.26	2.32	2.40
Composting	0.2	0.3	0.37	0.42	0.47	0.52	0.57	0.62	0.67	0.72	0.77	0.82
Energy recovery	0.61	0.63	0.62	0.68	0.74	0.8	0.86	0.92	0.98	1.04	1.1	1.16
Landfilling	2.95	2.83	2.76	2.78	2.47	2.36	2.17	1.91	1.6	1.38	1.13	0.91
Incineration	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02

Following table contains detailed information about methodology assumptions which were used for projections under Waste sector.

Tab. 2-58 Detailed information about projections for categories or subcategories under waste sector

	Projections 2017- 2040		
Category	**Activity data**	**Emission factors (CHMI 2018, IPCC 2006)**	**Methodology (CHMI 2018, IPCC 2006)**
5.A Solid Waste Disposal on Land	to 2024 obtained from WMP 2014 (MoE 2014), for 2025 - 2040 derived from WMP 2014 (MoE 2014) by extrapolation	Default	Tier 1
5.B Biological	to 2024 obtained from WMP 2014 (MoE	Default	Tier 1

Category	Projections 2017- 2040 Activity data	Emission factors (CHMI 2018, IPCC 2006)	Methodology (CHMI 2018, IPCC 2006)
Treatment of Solid Waste	2014), for 2025 - 2040 derived from WMP 2014 (MoE 2014) by extrapolation		
5.C Incineration and Open Burning of Waste	to 2024 obtained from WMP 2014 (MoE 2014), for 2025 - 2040 derived from WMP 2014 (MoE 2014) by extrapolation	Default	Tier 1
5.D Wastewater Treatment and Discharge	to 2024 obtained from WMP 2014 (MoE 2014), for 2025 - 2040 derived from WMP 2014 (MoE 2014) by extrapolation	Default	Tier 1

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

Emissions estimated up to year 2024 are based on assumptions and forecasted scenario in the Waste Management Plan (WMP) (MoE 2014) with the updated recent year values. Timeline has been prolonged up to 2040 by building upon the outlined scenario in WMP (MoE 2014) and by the new obligations of the Circular Economy WAM Package (EC 2018).

Scenario in WMP (MoE 2014) fulfils description of WEM, the document is taking into account all measures that are already in power, though some measures will be implemented in the future, based on the proposed roadmap. For both WEM and WAM scenarios it is expected that emissions will be decreasing for 2017 - 2040 compared to year 2016. Decrease of emissions is more obvious for WAM scenario which takes into account stricter landfill gas (LFG) recovery coefficients after a year 2025. It is expected that total emissions from Waste should decrease by 3% according WEM and by 26% according WAM compared to 1990. Overall results for the waste sector are shown in Tab. 2-59. Reported and projected emission trend for both scenarios is depicted on Fig. 2-22.

Tab. 2-59 Reported and projected emissions of GHG in Waste – WEM and WAM

	Reported emissions			Projected emissions					Difference [%]		
[Mt CO_2 eq.]	1990	2005	2016	2020	2025	2030	2035	2040	1990 – 2020	1990 – 2030	1990 – 2040
WEM	3.12	4.29	5.56	5.38	4.81	4.22	3.61	3.03	72.20	35.02	-2.92
WAM	3.12	4.29	5.56	5.38	4.80	3.95	2.77	2.32	72.20	26.38	-25.77

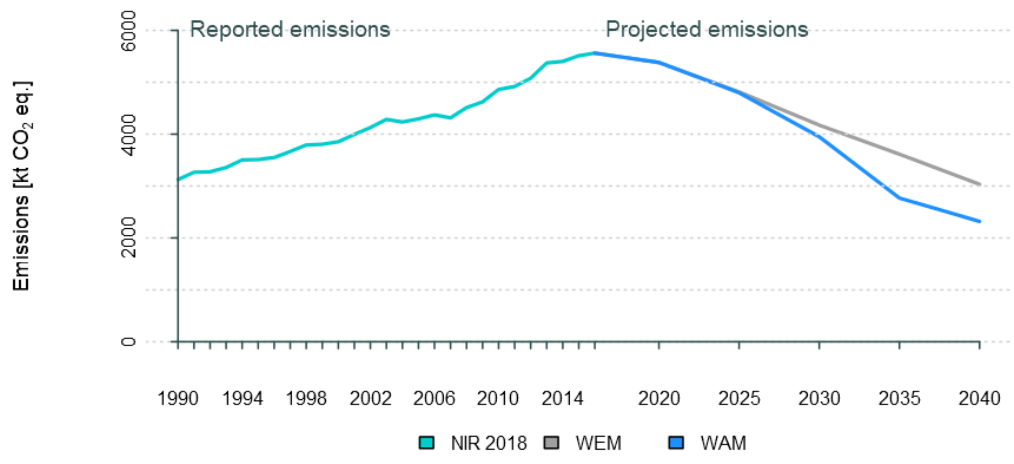


Fig. 2-22 Reported and projected emissions of GHG in Waste – WEM and WAM

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

Development of the WEM scenario is based on following assumptions: Municipal waste production is decreasing slightly, landfilling is gradually declining and composting and energy recovery is taking place instead (MoE 2014). The shift from landfilling to composting and anaerobic digestion decreases overall emissions because composting and anaerobic digestion produce lower emissions. As landfilling decreases a modest 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 2016, and due the effects of establishing a mandatory system for separate collection of biodegradable waste and its waste management.

Shift from landfilling to waste incineration is less visible here, as waste used for energy is reported under energy sector, where it does not leave a significant footprint when compared to the size of energy sector. Detailed breakdown of the emissions by gases and categories is shown in Tab. 2-60 and Tab. 2-61.

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

	Reported emissions			Projected emissions					Difference [%]		
[Mt CO_2 eq.]	**1990**	**2005**	**2016**	**2020**	**2025**	**2030**	**2035**	**2040**	**1990 – 2020**	**1990 – 2030**	**1990 – 2040**
CO_2	0.02	0.12	0.11	0.13	0.13	0.14	0.15	0.16	512.07	583.70	655.33
CH_4	2.87	3.93	5.18	4.96	4.35	3.71	3.06	2.44	72.89	29.44	-14.78
N_2O	0.23	0.24	0.26	0.29	0.33	0.36	0.40	0.43	24.70	54.62	83.76
Total	**3.12**	**4.29**	**5.56**	**5.38**	**4.81**	**4.22**	**3.61**	**3.03**	**72.20**	**35.02**	**-2.92**

Tab. 2-61 Breakdown of reported and projected emissions of GHG by categories in Waste - WEM scenario

	Reported emissions			Projected emissions					Difference [%]		
[Mt CO_2 eq.]	**1990**	**2005**	**2016**	**2020**	**2025**	**2030**	**2035**	**2040**	**1990 – 2020**	**1990 – 2030**	**1990 – 2040**
5. A Solid waste disposal	1.98	3.06	3.67	3.42	2.76	2.08	1.37	0.71	72.61	4.84	-63.92
5.B Biological treatment of solid waste	NO/IE	0.06	0.71	0.78	0.85	0.94	1.03	1.10	NA	NA	NA
5.C Incineration and open burning of waste	0.02	0.12	0.12	0.13	0.14	0.14	0.15	0.16	509.77	581.13	652.49
5.D Waste water treatment and discharge	1.12	1.05	1.06	1.06	1.06	1.06	1.06	1.06	-5.80	-5.61	-5.43
Total	**3.12**	**4.29**	**5.56**	**5.38**	**4.81**	**4.22**	**3.61**	**3.03**	**72.20**	**35.02**	**-2.92**

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

WAM scenario is almost identical to WEM scenario. The reason is that all planned changes in waste management practice are implemented according to the WMP (MoE 2014) document. The difference between WEM and WAM scenarios is increased recovery of landfill gas, which is increasing more sharply in WAM scenario due to increased pressure from renewables market. The effects can be observed in CH_4 value and in 5.A – Solid waste disposal category in tables below. Total amount of emissions is reduced by 26% compared to 3% decrease in WEM scenario from the base year 1990 until 2040. Breakdown by gases and source categories is shown in Tab. 2-62 and Tab. 2-63.

Tab. 2-62 Breakdown of reported and projected emissions of GHG by gases in Waste - WAM scenario

	Reported emissions			Projected emissions					Difference [%]		
[Mt CO_2 eq.]	**1990**	**2005**	**2016**	**2020**	**2025**	**2030**	**2035**	**2040**	**1990 – 2020**	**1990 – 2030**	**1990 – 2040**
CO_2	0.02	0.12	0.11	0.13	0.13	0.14	0.15	0.16	512.07	583.70	655.33
CH_4	2.87	3.93	5.18	4.96	4.34	3.44	2.22	1.73	72.89	20.03	-39.67
N_2O	0.23	0.24	0.26	0.29	0.33	0.36	0.40	0.43	24.70	54.62	83.76
Total	**3.12**	**4.29**	**5.56**	**5.38**	**4.80**	**3.95**	**2.77**	**2.32**	**72.20**	**26.38**	**-25.77**

Tab. 2-63 Breakdown of reported and projected emissions of GHG by categories in Waste - WAM scenario

	Reported emissions			Projected emissions					Difference [%]		
[Mt CO_2 eq.]	**1990**	**2005**	**2016**	**2020**	**2025**	**2030**	**2035**	**2040**	**1990 – 2020**	**1990 – 2030**	**1990 – 2040**
5. A Solid waste disposal	1.98	3.06	3. 67	3.42	2.75	1.81	0.53	0	72.61	-8.80	-100
5.B Biological treatment of solid waste	NE,IE	0.06	0.71	0.78	0.85	0.94	1.03	1.10	NA	NA	NA
5.C Incineration and open burning of waste	0.02	0.12	0.12	0.13	0.14	0.14	0.15	0.16	509.77	581.13	652.49
5.D Waste water treatment and discharge	1.12	1.05	1. 06	1.06	1.06	1.06	1.06	1.06	-5.80	-5.62	-5.43
5.E Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Total	**3.12**	**4.29**	**5.56**	**5.38**	**4.80**	**3.95**	**2.77**	**2.32**	**72.20**	**26.38**	**-25.77**

2.6.3 Sensitivity analysis

Projections of greenhouse gas emissions from Waste sector are based on calculation sheets used for emission estimates in National Inventory Report (CHMI 2018). Activity data is only variable which changes during 2017 – 2040 (please see chapter 2.6.1 for more detailed information about projections of activity data). Emission factors are constant during 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 emission factors used for emission estimates are constant during the projected period.

2.6.4 Difference between previously and currently reported projections

The waste forecast is based on WMP 2014 (MoE 2014) data with updated and extrapolated values. The Circular Economy Package (EC 2018) was added to PAMs, current projections are in line with the Circular Economy Package (EC 2018). Few methodological changes were implemented in current projections compared to previous projections (CHMI 2017). For category 5.A – Solid waste disposal, industrial correction factor of 0.26 Mt was added to landfilling data. A default 5% leakage from the anaerobic digestion processes and the subcategory 5.B.1.b – Other have been included in the category 5.B – Biological treatment of solid waste. The category 5.C – Incineration and open burning of waste has the forecast based on its incinerated I/HW tonnes which are applied to the spreadsheet with an extended timeline to 2040.

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