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INCLUDING

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Coordination

Ministry of the Environment of the Czech Republic

Supervision and final revision

Pavel Zámyslický	Ministry of the Environment
Kateřina Suchá	Ministry of the Environment
Michal Daňhelka	Ministry of the Environment

Compilation

Michal Daňhelka	Ministry of the Environment

Cooperation

We are grateful to the following persons and institutions for providing basic data and information:

Radim Tolasz	Czech Hydrometeorological Institute
Eva Lopatová	Czech Hydrometeorological Institute
Markéta Kučerová	Czech Hydrometeorological Institute
Miroslav Novák	Ministry of the Environment
Kamila Vondráčková	Ministry of the Environment
Jakub Horecký	Ministry of the Environment
Marie Petrová	Ministry of the Environment
Tereza Koubková	Ministry of the Environment
Vlastislav Kotrč	Ministry of the Environment
Tomáš Smejkal	Ministry of Industry and Trade
Viktor Havlice	Ministry of Industry and Trade
Radek Matějka	Ministry of Industry and Trade
Petr Dobrý	Ministry of Regional Development
Miroslava Ježková	Ministry of Finance
Jiří Jungr	Ministry of Agriculture
Tomáš Krejzar	Ministry of Agriculture
Vítězslav Slíva	Ministry of Education, Youth and Sports

Content

List of Abbreviations

AAU	Assigned amount unit
AEWA	Agreement on the Conservation of African-Eurasian Migratory Waterbirds
AnaEE	Analytical and experimental infrastructure for ecosystems
AOs	Aviation organizations
AS CR	Academy of Sciences of the Czech Republic
AUFAR	European Facility for Airborne Research
BaP	Benzo(and)pyrene
BAT	Best Available Techniques
BDC	Bilateral Development Cooperation
BDMW	Biologically degradable municipal waste
BMP	Best management practices
BPEJ	Estimated pedologic-ecological unit
BR	Biennial Report of the Czech Republic
BREF	Best Available Techniques Reference Documents
CAP	Common Agriculture Policy
CAS	Czech Academy of Sciences
CBD	Convention on Biological Diversity
CDA	Czech Development Agency
CDM	Clean Development Mechanism
CEI	Czech Environmental Inspectorate
CEMC	Czech Environmental Management Centre
CEMC	Czech Ecological Management Centre
CENIA	CENIA, Czech Environmental Information Agency
CEPA	Center for European policy Analysis
CEPF	Czech Environmental Partnership Foundation
CER	Certified emission reduction
CETS	Council of Europe Treaty Series
CF4	Tetrafluoromethane
CFC	Chlorofluorocarbons
CGS	Czech Geological Survey
CH_4	Methane
CHMI	Czech Hydrometeorological Institute
CHP	Biogas a hydro instalations

CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CLIDATA	Database of the CHMI with climatology data
CLRTAP	Convention on Long-Range Transboundary Air Pollution
CMS	Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention)
CNB	Czech National Bank
CNCS	Czech Nature Conservation Society
CNG	Compressed natural gas
CO	Carbon monoxide
CO_2	Carbon dioxide
CO_2eq.	Carbon dioxide equivalent
COP	Conferences of the Parties
COSMC	Czech Office for Surveying, Mapping and Cadastre
CPB	Cartagena Protocol on Biosafety
CRF	Common Reporting Format
CSEUR	Consolidated System of EU Registries
CTF	Common Tabular Format
CUEC	Charles University Environment Centre
CZK	Czech crown
CzSO	Czech Statistical Office
DC	Development Cooperation of the Czech Republic
DES	Data Exchange Standards
E85	Alternative fuel - a blend of 85 percent bioethanol produced from agricultural raw materials and 15 percent gasoline
EC	European Commission
ECCP	European Climate Change Programme
ECOP	Education for Competitiveness Operational Programme
ECU	European currency unit
EE&A	Environmental education and public awareness
EEA	European Environment Agency
EFA	ecological focus area
EFISCEN	European Forest Information Scenario Model
EMAS	Eco-Management and Audit Scheme
ERO	Energy Regulatory Office
ERU	Emission reduction unit

EU	European Union
EU ETS	European Union Emission Trading System
EUA	European Union Allowances
EUAA	European Union Aviation Allowances
EUR	EURO currency
EUROBATS	Agreement on the Conservation of Populations of European Bats
EUTL	European Union Transaction Log
EVVO	Environmental education and awareness raising and environmental consulting
FACCE	Food security, Agriculture and Climate Change
FAME	Fatty Acid Methyl Ester
FDC	Foreign development cooperation
FEP	Framework educational programmes
F-gases	fluorinated greenhouse gases
FMI	Forest Management Institute
FSF	fast start finance
GA CZ	Czech Science Foundation
GAECs	Good Agricultural and Environmental Conditions
GAV	Gross added value
GAW	Global Atmosphere Watch network
GC	Global Change
GCM	Global climate models
GCOS	Global Climate Observing Systém
GCRI	Global Change Research Institute
GDP	Gross domestic product
GEF	Global Environment Facility
GEO	Group on Earth Observations
GEOSS	Global Earth Observations System of Systems
Gg	Gigagram
GHG	Greenhouse gas
GIS	Green Investment Savings (Programme) (Czech Green Investment Scheme)
GMES	Global Monitoring for Environment and Security
GMO	genetically modified organism
GOOS	Global Ocean Observing System
GSN	GCOS Surface Network
GTOS	Global Terrestrial Observing System

GWh	Gigawatt hour
GWP	Global Warming Potential
HCFC	Hydrochlorofluorocarbons
HDV	Rainwater management
HFC, HFCs	Hydrofluorocarbons
HOMS	Hydrological Operational Multipurpose System of WMO
HWP	harvested wood products
IBCS	Intergovernmental Board for Climate Services
IBRD	International Bank for Reconstruciton and Development
ICAO	International Civil Aviation Organization
ICOS	Integrated Carbon Observation System
ICT	Information and Communication Technology
IEA	International Energy Agency
IFER	Institute of Forest Ecosystem Research Ltd.
IGBP	International Geosphere-Biosphere Programme
IMF	International Monetary Fund
IPCC	Intergovernmental Panel on Climate Change
IPPC	Integrated Pollution Prevention and Control
IROP	Integrated Regional Operational Programme
IRS	Integrated rescue system
ISO	International Organization for Standardization
JI	Joint Implementation
Km	Kilometer
KP	Kyoto Protocol
kW	Kilowatt
LA	level assessment
LCA	Life Cycle Assessment methodology
lCER	Long-term certified emission reduction
LCV	light commercial vehicle
LED	Light Emitting Diode
LFA	less favorable areas
LFG	landfill gas
LHP	large hydropower plant
LNG	Liquefied Natural Gas
LPG	Liquified petroleum gas (Propane-butane)

LULUCF	Land Use, Land Use Change and Forestry
MDC	Multilateral Development Cooperation
MEAs	Multilateral Environmental Agreements
MERO	Methyl ester of rapeseed oil
MEYS	Ministry of Education, Youth and Sports
MFA	Ministry of Foreign Affairs
NH_3	Ammonia
MIT	Ministry of Industry and Trade
MoA	Ministry of Agriculture
MoE	Ministry of the Environment
MoT	Ministry of Transport
MRD	Ministry of Regional Development
MU Brno	Masaryk University Brno
MW	Megawatt
MWh	megawatt hour
N	Nitrogen
N_2O	Nitrous oxide, dinitrogen oxide
NA	not applicable
NAP	National Allocation Plan
NAP CM	National Action Plan for Clean Mobility
NASA	National Aeronautics and Space Administration
NATO	North Atlantic Treaty Organisation
NC7	7th National Communicaiton of the Czech Republic under the UNFCCC
NDA	National Designated Authorities
NE	not estimated
NEEAP	National Action Plan for Energy Efficiency for the Czech Republic
NER	New Entrant Reserve
NERP	National Emissions Reduction Programme
NF	Nutritional Footprint
NGO	nongovernmental nonprofit organization
NIR	National Inventory Report
NIS	National Inventory System (greenhouse gases)
NMVOC	Non-methane volatile organic compounds
NO	not occuring
NO	Nitrogen oxide

NOx	Nitrogen oxides
NPP	nuclear power plant
NSRF	National Strategic Reference Framework
O_3	Ozone
ODA	Official Development Assistance
ODS	ozone depleting substances
OECD	Organization for Economic Cooperation and Development
OECD-DAC	OECD Development Assistance Committee
OP EIC	Operational Programme Enterprise and Innovations for Competitiveness
OPE	Operational Programme Environment
OPEI	Operational Programme Enterprise and Innovations
OPT	Operational Programme Transport
OSCE	Organisation for Security and Co-operation in Europe
PAH	Polycyclic aromatic hydrocarbons
PaMs	Policies and Measures
PCF	Prototype carbon fund
PES	primary energy sources
PFC, PFCs	Perfluorocarbons
Ph.D.	Doctor
PJ	Petajoule
POPs	Stockholm Convention on Persistent Organic Pollutants
PPP	Purchasing power parity
PPS	Purchasing power standard
PRTR	Protocol Protocol on Pollutant Release and Transfer Registers
QA	Quality Assessment
QC	Quality control
R&D	research and development
R&D IS	Research and Development and Innovations Information System of the Czech Republic
RCM	Regional climate models
RES	renewable energy sources
RMU	Removal unit
SDG	Sustainable Development Goals
SDS	Sustainable Development Strategy
SEA	Strategic Environmental Assessment

SEEA-EEA	System of Environmental-Economic Accounting; Experimental Ecosystem Accounting
SEF	Stadard Electronic Format
SEF CR	State Environmental Fund of the Czech Republic
SEP	State Environmental Policy
SEPs	school education programmes
SES	supported of energy sources
SF_6	Sulfur hexafluoride
SFSD	Strategic Framework for Sustainable Development
SHMI	Slovak Hydrometeorological Institute
SHP	small hydropower plant
SLE	significant landscape elements
SMW	solid municipal waste
SO_2	Sulphur dioxide
SOx	Sulphur oxides
SP EE and EC	State Programme of Environmental Education and Eco-counselling
SPA	specially protected areas
$(S)PM_{10}$	Suspended particulate matter under 10 microns in size
$(S)PM_{2.5}$	Suspended particulate matter under 2.5 microns in size
T.G.M. W.R.I.	T. G. Masaryk Water Research Institute
TA	trend assessment
tCER	Temporary certified emission reduction
TEN-T	Trans-European Transport Networks
TMA	maximum temperature
TMI	minimum temperature
TRC	Transport Research Centre
TSES	Territorial System of Ecological Stability
UN	United Nations
UNCCD	United Nations Convention to Combat Desertification in Those Countries Experiencing Serious Drought and/or Desertification, Particularly in Africa
UNDP	United Nations Development Programme
UNECE	The United Nations Economic Commission for Europe
UNEP	United Nations Environmental Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change

USA	United States of America
USD	American dollar
VOC	Volatile organic compounds
WAM	with additional measures
WCP	World Climate Programme
WEM	with existing measures
WHO	World Health Organisation
WHRU	waste heat recovery unit
WMO	World Meteorological Organisation
WMP	Waste Management Plan
WP	Work Package
WSEP	World Scouting Environmental Education Program
WTO	World Trade Organization
WWTP	waste water treatment plant

1 SUMMARY

Introduction

The Czech Republic, as a Party to the United Nations Framework Convention on Climate Change (Convention/UNFCCC), acceded to the Kyoto Protocol (KP) on 15 November 2001 and became a Party to the Paris Agreement on 4 November 2017. In March 2004 Czech Government adopted a National Programme to Abate the Climate Change Impacts in the Czech Republic which was dealing mainly with mitigation and adaptation policies and measures by 2020. In March 2017 the Czech Government adopted a new Climate Protection Policy of the Czech Republic replacing the original National Programme.

The Climate Protection Policy of the Czech Republic (Policy) sets new GHG reduction goals by 2020 and 2030 with a longer term outlook until 2050 which corresponds to the existing EU climate and energy goals, policies and legislation in place. The commitment of the Policy is to to achieve emission reduction targets in a cost-efficient manner. Measures are proposed in the following key sectors: energy, final energy consumption, industry, transport, agriculture and forestry, waste, science, research development, cross-cutting measures and voluntary tools.

Primary emission reduction targets

- Greenhouse gas reduction of 32 Mt CO_2eq. compared to 2005 until 2020
- Greenhouse gas reduction of 44 Mt CO_2eq. compared to 2005 until 2030

Indicative emission reduction targets

- Indicative level towards 70 Mt CO_2eq.of emitted greenhouse gases in 2040
- Indicative level towards 39 Mt CO_2eq.of emitted greenhouse gases in 2050

The first evaluation of the Policy took place in 2021. The emissions reduction target for 2020 was achieved and the Czech Republic is also on track towards the 2030 reduction target with effective implementation of additional measures. On the basis of the evaluation and the new targets coming from the EU Fit for 55 legislative package and the climate neutrality target for 2050 the update of the Policy should be presented to the Government by the end of 2023, together with the update of the State Energy Policy.

The Policy Statement of the Government from January 2022 includes among others the goals to create the conditions for energy transformation and development of coal regions to allow for a phase-out of coal by 2033 and to contribute to constructing at least one hundred thousand rooftop photovoltaic istallations by 2025.

The Strategy on Adaptation to Climate Change in the Czech Republic (Strategy) has been adopted by the Czech Government in October 2015 and is complemented by the National Action Plan on Adaptation to Climate Change (Action Plan) from January 2017. The Strategy presents observed climate change in the Czech Republic and defines the adaptation measures including their mutual linkages in connection to anticipated impacts of these changes. Both of these strategic documents were updated in 2021 based on their evaluation and updated Complex Study on Impacts, Vulnerability, and Sources of Risk Related to Climate Change in the Czech Republic.

National conditions

The Czech Republic is a parliamentary democracy; the supreme legislative body is a two-chamber Parliament. Executive power rests within the Government that is based on results of general elections into the lower house of Parliament – Chamber of Deputies. The Czech Republic is a member of UN, EU, NATO, OECD, WTO, IMF and many other notable international organizations.

Czech population reached 10 682 029 as of 30 September 2021; 70% of population lives in urban areas. Demographic projections indicate slight growth in population in the next ten years followed by a slight decrease until 2050. Large number of scattered municipalities is characteristic feature of the country (as of December 2021 there were 6 258 municipalities). Six cities haave population exceeding 100 000 (Prague, Brno, Ostrava, Pilsen, Liberec and Olomouc).

With 78 870 km^2 of territory the Czech Republic belongs among middle-sized European countries. Average elevation above sea level is 430 m, which exceeds the average European elevation of 290 m. The main European watershed traverses the country between the North, Baltic and the Black Sea. Long-term precipitation is 637 mm and approximately 25% of this volume is drained in the form of surface water. Alluvial plains and lowlands are mostly cultivated – cropland and meadows. Woods cover 1/3 of the territory and significantly influence micro- and mezzo-climate. Most of the woodland (economically exploited monocultures with prevalence of spruce and pine populations) has been artificially planted and does not correspond to natural species compositions.

The state of the environment considerably improved in the last 25 years, especially the ambient air quality and with respect to water protection and waste management. Significant levels of polycyclic aromatic hydrocarbons (PAHs) and particulate matter (PM) emissions however persist, generated by household coal-fired heating boilers and internal combustion engines. After 1990 the Government adopted key environmental legislation, which is continuously being improved upon in line with EU legislation. A number of strategic environmental documents were drafted in recent years addressing principles of sustainability. The most important document in this domain was *The Strategic Framework for Sustainable Development* of the Czech Republic (SFSD), adopted by the Czech Government in 2010. SFSD determined long-term objectives for three basic pillars of modern society development (economic, social and environmental). In 2017 the original SFSD was replaced by a new overarching strategic document *the Czech Republic 2030* which should help to improve the quality of life in the Czech Republic for present and future generations. This strategic document is also deemed as part of a joint effort for the sustainable development of the European Union and a contribution of the Czech Republic to the achievement of the global sustainable development goals adopted by the United Nations in 2015.

Climate

The Czech Republic lies within the Atlantic-continental area of the moderate climate zone of the northern hemisphere. Average annual temperature fluctuates in relation to geographic factors between 1.1 and 9.7 °C. It is estimated that until the end of this century the annual average temperature in the Czech Republic will rise up to 2 °C. The lowest temperature averages are recorded in mountainous regions along the northern, eastern and south-western borders of the territory. The warmest regions lie in altitudes not exceeding 200 m (lowlands in southeast and along the Elbe River). Average spring and autumn temperature oscillate around 8 °C, during the summer months the temperature rises to 17 °C on average, in winter the temperature drops to about 0 °C on average. Prague represents a specific region, as within its heat island[1] the average annual temperature is higher by approximately 2 °C above the value normal for its geographic location.

Regardless of considerable year-to-year fluctuations, there is an apparent trend of gradual rise in average annual temperature amounting to approximately 0.2 °C over 10 years. In the last two decades there has been an increase in average number of days with high temperature and decrease in days with low temperature in the Czech Republic, which complements the gradual growth of temperatures and growing temperature extremality. Number of summer days has increased by 43 on average, number of tropical days by 18, and conversely the number of frost days dropped by 88 on average and ice days by 32.

Similar trends in precipitation development are not apparent. Radar data however confirm that the frequency of rainstorms have grown over the last three decades.

Economy and greenhouse gas emissions

In 2013 the Czech economy moved on the trajectory of renewed recovery. The increasing consumer confidence was supported by low inflation and growing employment. Positive macroeconomic development culminated in 2015, mainly due to one-off factors. The unemployment rate has been the lowest in the whole EU since 2016. After slow rise during 2017 and 2019 Czech economy was deeply affected by the COVID-19 pandemic, as well as the whole world. In Czech Republic, like in many other EU countries, the main demand factor of the economic decrease was household consumption. The GDP in 2020 decreased by 5.6% which was the biggest fall in the history of Czech Republic. That effected also the level of employment which decreased by 1.5%. Despite that, the level of unemployment stays the lowest in the EU. The GDP increase by 3.3% in 2021 indicates slow recovery.

The energy intensity of the Czech economy decreased by 34.8 % between 2010 and 2020 and it reached 7.8 MJ/EUR in 2020, which is still almost double the energy intensity of EU27. The higher energy intensity can be partially explained by the structure of the Czech economy, which is more industrial compared to most of the other EU countries.

The Czech Republic generates sufficient volume of electricity to cover its domestic demand. The Czech Republic is still a major exporter of electricity, nevertheless net exports are gradually decreasing (and it is expected that due to the gradual phase-out of old power generation capacities, mainly coal fired power plants, the exported volumes of electricity will further decrease and the Czech Republic might also become net importer of electricity. More than half of the electricity production is generated in low-carbon sources, namely nuclear sources (36.9% in 2020) and renewable energy sources (14.3%). Solid fossil fuels, namely domestically extracted coal, are still important source in electricity generation (38.1%), but their role is gradually decreasing.

Exploitable lignite and hard coal deposits are low and the operational life of existing mines is roughly estimated from 10 to 50 years. Hard coal deposits in the Czech Republic are estimated

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[1] Beranová, R., Huth, R. (2003): Prague heat island during different synoptic conditions. Meteorological Bulletin, 56, no. 5, pp 137-142, ISSN 0026-1173.

to be depleted by 2030. However, the Government has decided to phase-out energy use of coal by 2033.

The Czech Republic has an extensive network of district heating based on centralized heat production. Centralized heating is still based predominately on fossil fuels, mainly coal, even though its role it gradually decreasing. More than 75% of heat is produced in combined heat and power production, which leads to savings of primary energy sources. Individual heating is dominated by natural gas, but other sources such as biomass play important role. Almost one fourth of heat is generated using RES.

The significance of RES in the Czech energy sector has been steadily growing. The overall share of RES in 2020 in final energy consumption (in EUROSTAT methodology) equalled 17.5%, which is 7 p.p. higher compare to 2010. The share of RES has also been increasing in all main sectors. The share of RES in power sector in 2020 equalled to 14.8%, in transport it reached 9.4% and in heating and cooling sector it amounted to 23.5%. In the year 2020 the generation of electricity from RES was app. 11.6 TWh, which is more than 5 TWh higher compared to the year 2010. The biggest contribution comes from bioenergy (43.8%) in the form of biogas (22.3%) and biomass (21.5%), followed by hydropower (29.5%). The other important RES are photovoltaic (19.7%), wind (6.0%) and renewable waste (1.0%).

Individual automobile transportation recorded a steady increase in passenger transport. Transport performance of road freight transport also shows an increasing trend. The performance and the number of passengers have increased in the passenger railway transport since the significant decline in 2009. Railway transportation in 1990 processed almost 70% of the total freight transportation in the Czech Republic, while today it is only approximately 21%. The vast majority of freight in the Czech Republic is transported by road. This is a problem particularly in terms of the high intensity of freight transport on the main routes, increased air pollution and degradation of transport network. Data for air transportation show sharp decrease in 2020 because of the COVID-19 pandemic. 30% decrease in public transport output was also observed.

In 1990, the transportation-generated emissions amounted to mere 5.7% of total CO_2 emissions in the Czech Republic. Until 2020 this value raised to 15.7%. Greenhouse gasses (CO_2, N_2O and CH_4) show increasing trend from 1990 to present.

The Czech Republic is traditionally an industrial country and industry represented 31% of the Czech GDP in 2020. Energy intensity of the industry has been falling considerably. While in 2010 the energy intensity of the industrial sector reached 230.3 MJ/thousand CZK, in 2020 this value was only 192.7 MJ/thousand. Introduction of new technologies, best available techniques (BATs) and measures leading to energy savings drove the decrease of energy intensity in industry. The emission production is not evenly distributed among individual sectors; the most intensive sectors are steel and metal works, refineries, cement and lime production. In a number of sectors, notably in paper and cellulose manufacture, glass-making, ceramics and chemical production and industrial energy generation (production of technological steam and electricity for own consumption) there has been a stabilization of emissions or even reduction. Industrial technologies, emitting large volumes of greenhouse gases, are covered by EU ETS.

Total waste generation increased by 19.3% between 2009 and 2020 and by 3.1% between 2019 and 2020 to 38,503.7 thous. t. Between 2009 and 2020, the total generation of non-hazardous waste increased by 22.0% and by 3.1% between 2019 and 2020 to 36,721.8 thous. t. and the total generation of hazardous waste decreased by 17.6% to a total of 1,781.8 thous. t.

Since 2009 there has been a 7.6% increase in the municipal waste generation. The total per capita generation of municipal waste in 2020 was 535.5 kg per capita. The share of municipal waste landfilled fell from 64.0% to 47.8% in the 2009–2020 period. Diversion from landfilling is increasing the share of municipal waste used for material recovery, which increased from 22.7% in 2009 to 38.6%. At the same time, the importance of energy recovery from municipal waste also increased, from 6.0% in 2009 to 12.6% in 2020.

Cropland represented 53.4% of the total area of the country (approximately 7.9 million ha) in 2020 (in 2003 the figure was 54.1%). Wheat remains the predominant crop. Development of organic farming shows a positive trend. The number of organic farms has been steadily growing in the recent years. Numbers of distributors and producers of bio food are also growing. At present time, the fertiliser application in the Czech Republic in comparison with the EU average is, more often than not, lower. In 2020, the CH_4, N_2O and CO_2 emissions reached the total of 7 841.83 kt CO_2 eq. Agriculture is the largest source of N_2O emissions (76% of the total N_2O emissions) and second largest source for CH_4 (30% of total emissions of CH_4).

Woodland area has been steadily growing, especially as a result of afforestation of infertile cropland (in recent years the annual gain was approximately 2 000 ha). The total area of woodland in 2020 reached 2 677 thousand ha, which represent approximately one third of the Czech territory (34.0% of the entire state territory). In 2020, 70.4% of forests were coniferous forests (76.5% in 2000) and 28.2% broadleaved (22.3% in 2000). Total wood supply in the Czech Republic has been growing and in 2020 it reached 701.1 million m^3.

Emissions from the LULUCF sector amounted to 12 771.80 kt CO_2 eq. in 2020, which corresponds to 10% of total national emissions. LULUCF sector is currently no longer a sink of CO_2. Starting with 2015 the removals decreased and resulted in emissions since 2018. The situation is caused by the extreme drought-induced accelerating bark-beetle outbreak calamity experienced in the Czech forestry in the recent years. The emissions are mainly driven by salvage logging operations. While the emissions from the LULUCF sector have probably peaked the Czech Republic may not reach sinks in this sector by 2030. Besides the serious impact of natural disturbances, the balance in the following years is also expected to be temporarily negatively affected by the planned increase in the share of broadleaved species.

National Greenhouse Gas Inventory System and emissions trends

Emission inventory is being maintained in line with the standard IPCC methodology. Emission factors and activity data that were used are included in the annual National Inventory Report[2]. National Inventory System (NIS) has been launched in 2005. The body responsible for its administration is the Ministry of the Environment, which delegated these powers to the Czech Hydrometeorological Institute (CHMI) as the organization responsible for coordination of emission inventory preparation and elaboration of the required data and text outputs.

CHMI has been tasked especially with the following:

- Management (coordination of cooperation among individual sector agents)
- General and cross-section issues including determining the uncertainties

[2] National Inventory Report and inventory data sets for each year are available at http://www.chmi.cz/files/portal/docs/uoco/oez/nis/nis_uv_cz.html

- QA/QC control procedures
- Data reporting in prescribed format - CRF (*Common Reporting Format*)
- Preparation of *National Inventory Report* (NIR)
- Cooperation with relevant UNFCCC and EU bodies
- Operation of complete archiving and documentation management system for the inventory.

Official greenhouse gas inventory outputs (CRF, NIR) are completed by the CHMI and submitted to the Ministry of the Environment for approval. The Ministry of the Environment cooperates further with other departments and state organizations, especially with the Czech Statistical Office (CzSO). Besides that, the Ministry of the Environment communicates with the European Commission and the UNFCCC Secretariat.

QA processes include control activities and review undertaken by third party, which is not involved in national inventory preparation. CHMI cooperated on QA processes with Slovak experts, who are involved in preparing the Slovak national inventory. The Ministry of the Environment, to whom CHMI submits national inventory results for evaluation and approval, also carries out reviews.

In 2020, the most important GHG in the Czech Republic was CO_2 contributing 83.3% to total national GHG emissions and removals expressed in CO_2 eq., followed by CH_4 9.2% and N_2O 4.3%. PFCs, HFCs, SF_6 and NF_3 contributed for 3.3% to the overall GHG emissions in the country.

Over the period 1990 - 2020 CO_2 emissions and removals decreased by 32.6%, CH_4 emissions decreased by 50.7% during the same period mainly due to lower emissions from 1 Energy and 3 Agriculture; N_2O emissions decreased by 42.7% over the same period due to emission reduction in 3 Agriculture. Emissions of HFCs and PFCs increased by orders of magnitude, whereas SF_6 emissions kept steady trend over the whole period.

In 2020, 84 581.01 kt CO_2 eq., that are 67.36% of national total emissions (including 4 Land Use, Land-Use Change and Forestry) arose from 1 Energy; 97.27% of these emissions arise from fuel combustion activities. The most important sub-category of 1 Energy with 49.19% of total sectoral emissions in 2020 is 1.A.1 Energy Industries, 1.A.2 Manufacturing Industries and Construction responses for 12.11% and 1.A.3 Transport for 21.03% of total sectoral emissions. From 1990 to 2020 emissions from 1 Energy decreased by 47.52%.

2 Industrial Processes is the second largest category with 12.13% of total GHG emissions (including 4 Land Use, Land-Use Change and Forestry) in 2020 (15 229.96 kt CO_2 eq.); the largest sub-category is 2.C Metal Production with 39.04% of sectoral share. From 1990 to 2020 emissions from 2 Industrial Processes decreased by 11.71%.

3 Agriculture is the third largest category in the Czech Republic with 6.25% share of total GHG emissions (including 4 Land Use, Land-Use Change and Forestry) in 2020 (7 841.83 kt CO_2 eq.); 46.21% of these emissions arose from 3.D Agricultural Soils. From 1990 to 2020 emissions from 3 Agriculture decreased by 49.45%.

4 Land Use, Land-Use Change and Forestry is contributing with 10.17% to the total GHG emissions (12 771.80 kt CO_2 eq.). Subcategory 4.A. Forest Land contributes to these emissions by more than 100%; the total emissions are lowered thanks to the removal in 4.G Harvested Wood Products and 4.C Grassland.

5 Waste contribution to the total GHG emissions is (including 4 Land Use, Land-Use Change and Forestry) 4.09% in 2020; 64.13% share of these emissions arose from 5.A Solid waste disposal. Emissions from 5 Waste increased from 1990 to 2020 by 70.38% to 5 135.78 kt CO_2 eq.

National emission trading registry

The Czech greenhouse gas emissions trading registry (ETR) has been administered since 2005 by OTE corp. under authorization of the Ministry of the Environment. As of June 2012 the single Union Registry has been established. The ETR allows access only to duly authorized representatives of the account holders. All legal entities operating its instalations which have the obligations, pursuant to Act No. 383/2012 Coll., on conditions of trading with GHG emission allowances have the obligation to open an account in ETR. Since 2012 the same obligation is imposed to aircraft operators who fall into the EU Emissions Trading System (EU ETS).

The Registry information system had been reviewed, in terms of DES, by the UNFCCC Secretariat within the framework of the initiation procedure prior to integration with EUTL[3] and further by using and set of testing scenarios. The Registry has undergone all these tests successfully and received the necessary certifications on 1 July 2012.

Policies and measures

In the Czech Republic, there are several levels of measures used to reduce greenhouse gas emissions (strategic, legislative and programming) or to help to adapt to climate change negative impacts. Since 2000, the Czech Republic has been implementing a system of strategic and operational planning, which is being continuously modified in line with the Czech international commitments and relevant EU climate and energy policies and legislation. Legislative framework determines institutional responsibilities for coordination and implementation of programmes as well as imposing regular review of their impacts.

Wider strategic framework is created primarily by the following documents:

- Czech Republic 2030 (adopted by the Czech Government in 2017),
- National Reform Programme (updated annually, last update in 2022),
- Strategy of the Regional Development 2021+ (adopted in 2019).

The most important strategic documents with direct or demonstrable indirect effect on greenhouse gas emissions:

- State Environmental Policy of the Czech Republic 2030 with a view to 2050
- Climate Protection Policy of the Czech Republic
- National Emission Reduction Programme
- National Energy and Climate Plan of the Czech Republic
- Strategy on Adaptation to Climate Change in the Czech Republic
- National Action Plan on Adaptation to Climate Change
- State Energy Policy
- National Action Plan for Clean Mobility

[3] European Union Transaction Log

- Waste Management Plan 2015 – 2024
- The Czech Recovery and Resilience Plan

Emission projections scenarios

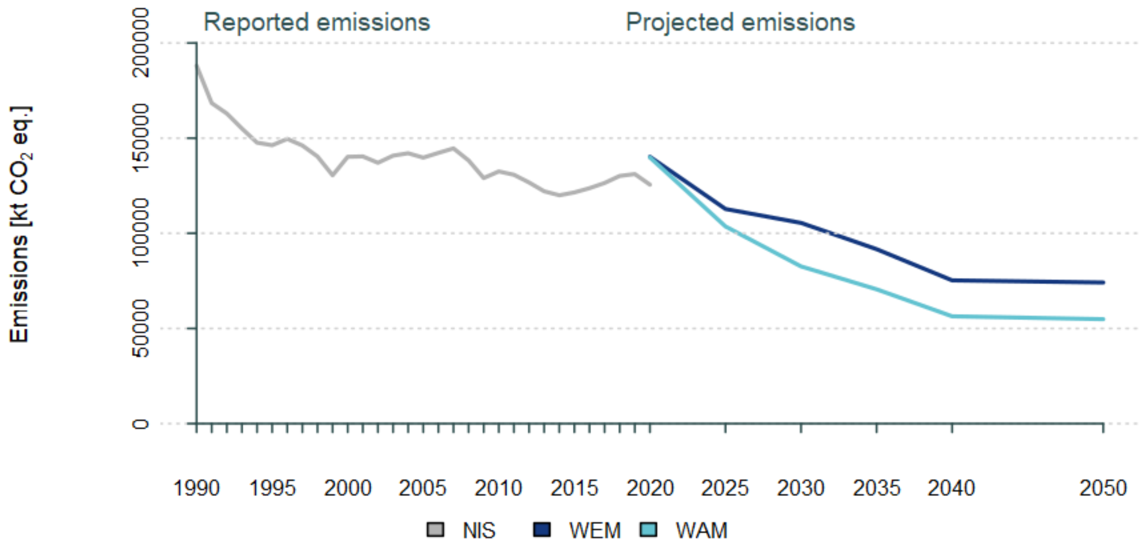
Projections have been prepared in line with the methodological guidelines for projection compilation[4] and in line with the Regulation (EU) No 525/2013. Projections contain two scenarios:

- With existing measures (WEM) - with measures implemented and effective as of the date when preparation of projections began (July 2020);
- With additional measures (WAM) - with measures which are going to be implemented in near future or which are planned to be implemented in future.

The total GHG emissions are projected to slightly increase in next few years for both WEM and WAM scenarios. Around the 2025 the emissions will start to decrease and the declining trend continues until 2040 when it flattens and stays stagnant until 2050. The difference between WEM and WAM scenario is caused by additional measures in 1. Energy and 5. Waste sectors. Total GHG emissions for WEM scenario are projected to amount to 74.15 Mt CO_2 eq. in 2050, representing 61% decrease of emissions compared to 1990. For WAM scenario the total GHG emissions in 2050 will amount to 54.88 Mt CO_2 eq., representing 71 % decrease of emissions compared to 1990.

Historical emissions along with both projections (WEM and WAM) are given in the figure below.

Figure 1.1: Total reported and projected GHG emissions – WEM, WAM scenario (including LULUCF)



Source: CHMI

[4] UNFCCC Reporting Guidelines on National Communication, FCCC/CP/1999/7, part II

Estimated vulnerabilities, climate change impacts and adaptation measures

The rate of observed temperature change in the Czech Republic expressed in trends over 10 years has increased. The scenario data are compared with the 1981-2010 normal, which is higher than the original 1961-1990 normal used in the 7. National Communication. This corresponds to lower estimates of temperature change. For precipitation, the signal of change is still ambiguous, with models currently projecting a slight increase in annual totals. Significant projected changes in extreme temperatures are reflected in the estimates of tropical and frost days. Air temperature increase for the period 1961-2016 is statistically significant in all seasons. A positive trend of 0.32 °C/10 years is observed for the annual values for the period 1961-2016.

Based on all available experiments, annual air temperature in the Czech Republic will increase by 2.0 °C by the end of the 21st century (RCP4.5) or by 4.1 °C in the RCP8.5 scenario compared to the reference period (1981-2010). A more significant change will occur in the maximum and minimum air temperatures. The models predict that the highest increase in maximum air temperatures will occur in winter and the lowest in spring.

Precipitation predictions based on all 11 RCM experiments show a slight increase of 7-13% for RCP4.5 or 6-16% for RCP8.5. Predictions of future changes in the precipitation regime are highly uncertain. A more detailed analysis shows that the increase in total precipitation in the model results mainly consists of intense precipitation events with totals greater than 20 or 50 mm, while the total number of precipitation days remains unchanged.

The negative impacts of climate change on water management can already be observed in some river basins in the Czech Republic in the form of a significant decline in runoff in the observed series since 1961.

Agriculture is probably the sector where climate change is currently having the greatest impact. It is key to food security and the combination of climate change and adaptive agriculture will significantly affect the level of ecosystem services in our landscapes. The impacts of a changing climate in the agricultural sector are mainly connected to rising temperatures, which is also one of the main factors influencing changes in the water balance. In particular, the lowlands or regions formerly at the very peak of productivity (i.e. the original beet and maize production areas) will be increasingly vulnerable to episodes of agricultural drought, with significant effects on the formation of the yield-forming elements of individual crops and consequently on the size and quality of yields. Recent studies have also shown that inter-annual variability in crop yields can be expected to increase due to increased frequency and intensity of adverse situations for crop production such as significant drought episodes, occurrence of high temperature stress at sensitive developmental stages, low temperature damage, etc. It is evident that there is a risk of reducing the potential productivity of key agricultural areas in the Czech Republic, as the effective length of the growing season is stagnating and possibly decreasing due to lack of moisture, primarily in the lowlands.

The main impacts of climate change that pose risks to **forestry** are rising air temperatures, particularly spring and summer temperatures, decreasing summer precipitation and increased evapotranspiration. This leads to higher drought severity, increased frequency of dry periods and increased length of dry periods. This progression of meteorological factors is significantly weakening our current economic forests. The biotic agents, especially bark beetles, play a decisive role in tree mortality. Their increased activity is partly due to the weakened resistance of trees due to drought. Increased incidence of storm winds may contribute to the disruption of declining forests. The shift of forest vegetation stages (FVS), which are the basis of the system for differentiated forest management, is related to the increasing temperature. In accordance with projected climate change scenarios, a shift in habitat conditions by at least two FVS is expected by the end of the 21st century.

The main impacts of climate change in **urban environments** include increased temperatures, flooding and heavy rainfall and, in the future, water scarcity. Increasing temperatures will affect water circulation (quantity, quality) and the availability of water resources. Climate change is also likely to affect air conditions (humidity, quality), and some extreme events may become more frequent. This will have an impact on the population (health, well-being), buildings and public infrastructure (disruptions and failures of transport and technical infrastructure networks). A major anticipated manifestation of climate change in the urban environment is the further intensification of the urban heat island, especially in the absence of adaptation measures aimed at increasing evaporation from water and green features in cities. With expected further population growth in large cities, there may be greater exposure to the negative impacts of extreme hydrometeorological events, including floods, heavy rainfall and drought and water scarcity.

Climate change creates clear challenges for the **energy sector**. In addition to the need to reduce emissions, the energy sector faces increasing risks from a range of climate change impacts that present a serious threat to energy security. Climate change affects not only on the functioning of the energy sector and its actors, but also on society as a whole, which relies on the provision of energy services. This includes industry, commercial operations, hospitals, schools and other social services, as well as the individual households that rely on them. Increasing the resilience of the energy sector thus protects not only energy companies, but also the economies and populations that rely on energy services. A wide range of climate change impacts could affect the core components of the energy sector: generation, transformation, transport and storage, but also demand. These impacts vary by region, and the risks depend on the vulnerability of the area to physical exposure to hazards. Industry and energy are some of the slowest adapting sectors due to the extremely high costs, time-consuming construction of sources and linear structures, and therefore the long implementation period of adaptation measures.

In the **transport sector**, the main economic impacts of climate change can be expected in the form of changes in the costs of maintaining, repairing and ensuring the functionality of infrastructure.

Because of climate change, the population of the Czech Republic may be more exposed to some hazardous hydrometeorological phenomena and their impacts in terms of threats to **life and health**. Summer mortality is likely to increase due to the occurrence of heat waves. The elderly and socially excluded population, including young children, are likely to be most at risk. Preventive measures will need to specifically address the population from socially excluded areas. Increased mortality during heat waves will particularly affect populations outside hospitals or other facilities (vulnerable populations without social supervision), and outreach health and social services will need to be strengthened. At the same time, the resilience of the population is increasing over time, with younger age groups no longer affected by mortality due to high temperatures. A positive effect of climate change is the reduction in cold-related mortality. There will be an increase in hospital admissions and deterioration in the health of populations with chronic diseases of all age groups due to heat waves. Conditions for the proliferation of pathogens in natural waters and food will be created. Drought is putting drinking water sources at risk. Water conservation and unnecessary use of drinking water must be addressed.

Climate change will have both negative and positive effects on **tourism** in the Czech Republic. On the one hand, rising average temperatures will extend the tourist season and thus (after appropriate investments in infrastructure) increase the income of the sector. On the other hand, it will shorten the winter tourist season and have a negative impact on winter tourism in mountain areas.

The main expected impacts and risks of climate change on the population include:

- Increased frequency, intensity and variability of extreme weather events (especially prolonged droughts, extreme temperatures, heavy rainfall and their consequences,
- floods and flash floods,
- long-term climate change in the sense of a gradual increase in average annual temperatures of 2 °C or more, a gradual decrease with or change in the distribution of precipitation, with the consequent threat to ecosystem services,
- secondary impacts such as natural phenomena induced technological accidents (NATECH), subsequent manifestations of climate change impacts outside the Czech Republic such as migration waves or threats to raw material and food security.

Adaptation measures

The Czech Republic is already implementing a number of adaptation measures, especially in connection with water regime in the landscape and water management, forestry, agriculture and ecosystems.

The *Strategy on Adaptation to Climate Change in the Czech Republic* (hereinafter referred to as “Strategy”) was first adopted by the Czech Government in October 2015 and is implemented by the *National Action Plan on Adaptation to Climate Change* (hereinafter referred to as “Action Plan”) since January 2017. Preparation of both the Strategy and Action Plan was coordinatedby the Ministry of the Environment in cooperation with a number of Ministries and relevant scientific institutions. The Action Plan contains a list of adaptation measures and tasks, including responsibilities for implementation, deadlines, identification of relevant funding sources and an estimate of the costs of implementing the measures.

The first update of both the Strategy and Action Plan was approved by the Government of the Czech Republic on 13 September 2021. More than 170 experts from public, scientific and non-profit institutions participated in the update of both documents. The materials are based mainly on expert documents prepared by the Ministry of the Environment (CHMI and CENIA) with the support of the Czech Academy of Sciences (especially CZECHGLOBE - Institute of Global Change Research of the Czech Academy of Sciences) and a number of other research organisations.

The following documents were the key analytical basis for updating the adaptation strategy and action plan:

- Update of the 2015 Comprehensive Study of Impacts, Vulnerability and Sources of Climate Change-related Risks in the Czech Republic (team led by the CHMI, 2019);
- Evaluation of the implementation of the National Action Plan for Adaptation to Climate Change (CENIA and MoE, 2019);
- Vulnerability assessment of the Czech Republic in relation to climate change as of 2017 (CENIA, 2019).

The Strategy, which is based on the relevant EU documentation, has been adjusted to specific conditions of the Czech Republic. The Strategy presents observed climate change and defines the adaptation measures including their mutual linkages in connection to anticipatedimpacts of these changes.

Adaptation measures are proposed in the following sectors (fields of impact of climate change):

- Forest management
- Agriculture
- Water regime in landscape and water management
- Biodiversity and ecosystem services
- Health and hygiene
- Urban landscape
- Tourism and recreation
- Industry and energy sector
- Transportation
- Cultural heritage
- Safe environment.

Financial resources and technology transfers

The Czech Republic is not a party to Annex II to the Convention and as such is not obliged to adopt measures, in line with Article 12.3 of the Convention and fulfil obligations pursuant to Articles 4.3, 4.4 and 4.5 of the Convention and provide additional financial sources. Nevertheless, the Czech Republic as the EU Member State, along with other developed countries committed itself at the 15th session of the Conference of Parties to the Convention in December 2009 in Copenhagen, to a goal of mobilizing jointly USD 100 billion annually by 2020 to address the needs of developing countries in the context of meaningful mitigation and adaptation actions and transparency on its implementation.

The Czech Republic has been providing climate specific support to developing countries since 2010. The development cooperation of the Czech Republic is the main means through which the climate financing and the technology transfer support have been delivered to developing countries. For the reporting purposes the climate specific funding has been identified in accordance with the OECD-DAC methodology. Only projects with adaptation or mitigation RIO Markers (significant or principal objective) are accounted towards the climate specific funding. The development cooperation has two main delivery channels a) the bilateral development cooperation and b) the multilateral development cooperation.

Key strategic document is the Development Cooperation Strategy of the Czech Republic 2018–2030, which defines territorial and sectoral priorities of foreign development cooperation of the Czech Republic and reflects international commitments and actual challenges in development cooperation area.

Research and systematic observation

Research on aspects connected with the current state and development of the climate system is concentrated particularly in the following institutions:

- Institutions of the Academy of Sciences of the Czech Republic
- University departments
- Sectoral institutions (Czech Hydrometeorological Institute; National Institute of Public Health; the T.G. Masaryk Water Research Institute, public research institution; Czech Geological Survey) and other research institutes

The research, which is part of the basic tasks of the individual institutions, is financed both from their budgets and also through the grant schemes. Some projects are carried out in the framework of international cooperation and co-financed by foreign partners – both on the EU level (programmes Horizon 2020 and Horizon Europe) and on the bilateral basis (e.g. with neighbouring countries, Norway and Israel).

Systematic observation of the climate system is carried out mostly by the Czech Hydrometeorological Institute (CHMI) which performs the function of the State institute for the area of air quality protection, hydrology, water quality, climatology and meteorology, with a competence to establish and operate State monitoring and observation networks, including international data exchange pursuant to the WMO principles. The Czech Hydrometeorological Institute is responsible for National Greenhouse gas inventory and database. Other institutions carry out monitoring for their own needs, usually for a limited period of a certain project.

Environmental education and public awareness

The obligation to promote environmental education and public awareness (EE&A) arises from valid legislation, the fundamental statute being Act No. 123/1998 Coll., on the right to information on the environment awareness and Act No. 561/2004 Coll. on School Education.

The State Programme of Environmental Education and Eco-counselling for 2016–2025 (SP EE and EC) is a key national strategy of the Czech Republic for the field of environmental education and eco-counselling (EE and EC), defining a structured vision, strategic areas, objectives and measures, the implementation of which includes not only state administrative authorities, but also regions, municipalities, schools, including universities, specialised facilities such as ecological education centres and eco-counselling organisations, and other entities established by the public administration, as well as private non-profit organisations, educational and research institutions, museums, zoos, botanical gardens, forestry institutions, libraries, church facilities, etc. SP EE and EC constitutes methodological support for drawing up regional and municipal environmental education and eco-counselling concepts and evaluating the impact of all forms of such activities at all levels.

One of the key topics of the SP EE and EC is “Climate in context”. The main goal is to address all important targeted groups to understand the causes of climate change and their negative effects and impacts on the Czech Republic, Europe and the world and the ability to learn and implement measures for both mitigation (reducing greenhouse gas emissions and especially moving away from fossil fuels) and adaptation (adapting to the negative impacts and consequences of climate change, especially reacting to extreme weather events).

The State Programme is increasingly focusing on climate education in its implementation Action Plans for 2019-2021 and 2022-2025 period. State support goes and is planned to go mainly to eco-centers and to schools.

Organizations in the Czech Republic participate in a number of international projects concerned with environmental communication, education, and public awareness. Some of these activities are supported methodically and financially directly by the Ministry of the Environment and Ministry of Education, Youth and Sports.

2 NATIONAL CONDITIONS

2.1 Government Structure

The fundamental constitutional arrangement, defining positions and tasks of the major state institutions, is laid down by the Constitution of the Czech Republic, which was adopted in 1992. The Czech Republic is a parliamentary democracy with division of powers between the legislative, executive and judicial branches of the Government. President is the head of the State, elected directly by the electorate for a five years term. The supreme legislative body of the land is the two-chamber Parliament, comprising of the Chamber of Deputies (lower house) and the Senate, which adopts all proposed bills, approves international treaties, conventions, protocols and other important political strategic documents in the industrial, military, environmental, agricultural and other sectors. The executive powers rest with the Government, which is formed on the basis of elections into the Chamber of Deputies. Its members usually come from the political parties, which obtained the strongest mandate from the electorate.

Since 1 January 2000, constitutional Act No. 347/1997 Coll., established 14 higher territorial self-governing units – Regions – whose size corresponds to similar administrative units in the EU defined as NUTS 3. Regional Authorities act as the local bodies exercising delegated powers of the state Government; a Director General heads Regional Authority. The head of each regional county is a governor; in Prague the head is the Mayor.

Regions represent a self-governing level between the Government and local municipalities, be it cities, towns or smaller units. Regions ensure selected functions and services to citizens within the framework of socio-economic and other development (incl. environmental services) based on their specific regional needs, better local knowledge and independent financial governance. Municipalities are currently the only self-governing units managed by the locally elected municipal and city boards of representatives headed by mayors.

In the environmental sector, the highest executive body is the Ministry of the Environment established on 19 December 1989 by Act No. 173/1989 Coll. as of 1 January 1990 to function as the central body of State administration and supreme supervising body in all matters related to the environment.

The Ministry of the Environment acts as the central executive body of the State administration in the following areas:

- transition to a low-carbon economy
- protection of natural accumulation of water
- protection of water sources and protection of subsurface and surface water quality
- protection of air
- protection of climate system
- adaptation to climate change
- protection of nature and landscape
- protection of agricultural land fund
- performance of state geological service
- protection of mineral deposits, incl. protection of natural resources and ground water

- geological work and ecological supervision of mining
- waste management
- evaluation of environmental impact assessment and its impact on the environment, incl. cross-border impacts
- game-keeping, fishery and forestry in national parks
- state environmental policy.

In order to exercise control activities of the Czech Government, the Ministry of the Environment coordinates activities of all other ministries and other central State administration bodies in all matters relating to the environment.

At present time, the Ministry of the Environment is divided into six expert sections (Directorate of State Secretary, Directorate of Environmental Economics, Directorate of State Administration, Directorate of Nature and Landscape Protection, Directorate of Environmental Protection and Directorate of Climate Protection).

The Ministry of the Environment is also the founding body of expert institutions such as the Czech Hydrometeorological Institute, the T.G. Masaryk Water Research Institute, the Agency for Nature Conservation and Landscape Protection of the Czech Republic, Czech Environmental Information Agency (CENIA), the State Environmental Fund of the Czech Republic, the Czech Geological Survey, the Silva Tarouca Research Institute for Landscape and Ornamental Gardening.

The Czech Environmental Inspectorate (CEI) is an independent organisational unit of the Ministry of the Environment. CEI is an expert body of State administration charged with supervision and enforcement of compliance with environmental standards in the Czech Republic. It also supervises compliance with binding decision issued by other state bodies in the environmental sector. CEI was established in 1991 by Act No. 282/1991 Coll. on the Czech Environmental Inspectorate.

2.2 Population

The Czech Republic had population of 10 682 029 as of 30 September 2021, which places it at the 10th place in European Union.

Evenly redistributed average population density of 136 inhabitants per km^2 makes the Czech Republic one of relatively densely populated countries in Europe. High population density and high urban dwellers ratio (70 %) means that a large number of inhabitants live in areas with disrupted environment, especially due to emissions from intensive traffic, household heating using solid fuels mostly in smaller municipalities and other local negative impacts.

In 2018 the Czech Statistical Office projections related to demographic development in the Czech Republic indicated that the future trends concerning population are not going to deviate a lot from current trends: in the next 10 years the Czech population will continue to grow up to 10.8 million and this growth will be followed by a short stagnation and a slight decrease afterwards. According to this projection, there would be around 10.5 million inhabitants in 2050 in the Czech Republic. The demographic projection also anticipates that the most significant characteristic of demographic development in next decades will be continuous increase of inhabitants over 65 years. It is expected that in 2050 the share of 65+ inhabitants will be higher by approximately 8% (28.5% against currently approximately 20.5%).

From the perspective of demographics, one of the issues with principal importance is the change in education structure. According to a study published by the Research Institute for Labour and Social Affairs of the Czech Republic, it is anticipated that by 2050, the number of inhabitants with completed university education will grow. Given that emphasis is put on the increased environmental awareness from the lowest levels of school education, it is anticipated that the population's awareness of the importance of prevention and resolution of environmental issues will also grow.

2.3 Geographic conditions

With area of 78 870 km^2, the Czech Republic is one of the small to mid-sized countries and currently ranks at the 15th place in Europe by size. The highest mountain is Sněžka in the Giant Mountains (1 603 m above sea level), lowest point in the country is located near Hřensko, in place where the River Elbe crosses into Germany (115 m above sea level). From the perspective of altitude, the lowlands and territory generally under 200 m above sea level take up 5.0%, areas between 200–500 m above sea level take up 74.1 %, areas 600–1 000 m above sea level take up 19.3% and areas with altitude exceeding 1 000 m above sea level take up 1.6% of the territory. Average altitude is 450 m, which is higher than the average altitude in Europe (315 m).

The divide among the main watersheds of Europe passes through the Czech Republic (the North, Baltic and Black Seas). This position on the main European divide is not favorable from the standpoint of water management, as most rivers have their source here. Thus, precipitation becomes the main source of water. The long-term average precipitation equals 686 mm and approximately 25% of this amount flows out of the country in watercourses. The river network in the Czech Republic has a density of 0.73 km/km^2. The vast majority of the territory of Bohemia is drained by the Elbe into the North Sea, the major part of Moravia is drained by the Morava River into the Danube and Black Seas and part of Moravia is drained by the Odra River into the Baltic Sea. The fan-shaped river network in the Odra watershed is characterized by the concentrated confluence of larger rivers in the Ostrava basin with an elevated risk of floods. Compared to the surrounding countries, there are only a very few lakes here (in the Šumava area). Artificial water reservoirs are far more numerous, with more than 24 000 located in the country, the vast majority of which are fishponds. Mineral springs are very common, occurring in about 350 locations.

The current condition of the biosphere is the result of natural developments over the last several thousand years. The vegetation in valley floodplains and lowlands corresponds mainly to agricultural land. Lowland meadows cover large areas. Forests are the most important of all plant communities (about 1/3 of the area of the country), and form a microclimate and mezoclimate, absorb more solar radiation, reduce wind speed and affect outflow conditions. Most present-day forest stands were planted artificially and do not correspond to the original species composition of the forests. Single-species stands with a predominance of spruce and pine are significantly threatened by climatic situation in latest years. The development of the contemporary landscape is affected primarily by secondary ecosystems. Original, natural ecosystems are scarce in the landscape. A large part of the country consists of fields, vineyards, orchards and gardens, used for food production.

The Czech Republic is characterized by scattered settlement structure, based historically on the large number of municipalities (there were 6 258 municipalities as of 12 December 2021) – only a small fraction of these municipalities can be called towns by international standards. Six cities have more than 100 thousand inhabitants (Prague, Brno, Ostrava, Plzeň, Liberec and Olomouc). Compared to the other countries of Central Europe, the Czech Republic has a smaller number of medium-sized and especially large cities. Territorial differences in the character of settlements are significantly affected by natural conditions. The areas of the uplands of central, southern and western Bohemia, which do not have very favorable conditions for agriculture, have a dense network of small settlements, while the more fertile lowlands of Bohemia and especially central and southern Moravia have larger rural settlements, frequently with 1–2 thousand inhabitants.

2.4 Protection of the Environment

2.4.1 Development of legislation and strategic documents

The state of the environment has markedly improved over the course of the last twenty years, especially with regard to air quality, water protection and waste management. On the other hand, the environment remains in several aspects unsatisfactory (for instance the dust particle emission levels) and represents, in the affected areas, a risk to both human health and the ecosystems.

A number of key component legislative acts were adopted after 1990, and this is being continuously updated to comply with EU legislation, especially in the areas of protection of air, water, waste management and protection of nature and the landscape. The following norms belong among the most important legislation:

- Act No. 134/2016 Coll. on Public Procurement
- Act No. 165/2012 Coll., on supported sources of energy, as amended
- Act No. 383/2012 Coll., - on Conditions of Trading with Greenhouse Gas Emission Allowances
- Act No. 201/2012 Coll., on Air Protection ;
- Act No. 73/2012 Coll., on ozone depleting substances and fluorinated greenhouse gasess, as amended
- Act No. 254/2001 Coll. regulates Protection of Waters, their use and associated rights;
- Act No. 185/2001 Coll. on Waste management defined fundamental principles of waste management, objectives and measures leading to their fulfilment as defined in the Waste Management Plan of the Czech Republic 2003-2013;

- Act No. 114/1992 Coll. on Protection of nature and the landscape defines what constitutes general protection of territories and species;
- Act No. 100/2001 Coll., on Environmental Impact Assessment;
- Act No. 76/2002 Coll., on integrated pollution prevention and control, on the integrated pollution register and on amendment to some laws (the Act on integrated prevention);
- Act No. 289/1995 Coll., on Forests.

In addition, a number of strategic environmental documents covering protection of the environment incl. principles of sustainable development were adopted. The most important of these are: the *State Environmental Policy (SEP)*, updated in 2021, the *Strategy for Sustainable Development of the Czech Republic* (2004), and the strategic framework *Czech Republic 2030*.

The Czech Government approved the *State Environmental Policy* in 2013. The latest update from 2021 is the *State Environmental Policy of the Czech Republic 2030 with outlook to 2050*. SEP defines priority problematic areas in relation to the environment in the Czech Republic, formulates strategic and specific objectives based on these areas, and outlines their possible solutions by examples of types of measures whose implementation should lead to an effective protection of the environment and its improved condition.

The topics addressed by this policy are divided into three main areas (Environment and Health, Climate Neutral and Circular Economy, Nature and Landscape), 10 strategic objectives and 32 specific objectives. A vision for 2050 was formulated for each of the three areas. The vision for 2050 also includes the following: „The society and the economy have adapted to climate change and consume as little non-renewable natural resources and hazardous substances as possible while making extensive use of secondary raw materials and zero emission energy sources. Sustainable use of the landscape and biodiversity are perceived as one of the pillars of high quality of life and contribute to the mitigation of climate change effects.“

On 19 April 2017 the Czech Government adopted an overarching strategic document *Czech Republic 2030* which effectively replaced the Strategic Framework for Sustainable Development of the Czech Republic from 2010. It indicates the direction for sustainable development of the Czech Republic for the next decade. The document sets out goals and targets to be accomplished by the 2030 and consists of a detailed development analysis and strategy for sustainable development that should be reflected in all sectoral and regional strategies. It outlines six national priority areas (people and society; economic model; resilient ecosystems; municipalities; global development; and good governance). Another segment of the document consists of an impact analysis of global megatrends on national development.

Among strategic goals of the Czech Republic 2030 which should directly contribute to accomplishment of the Agenda 2030 goals and targets is the active participation of the Czech Republic in international organisations based on national priorities, supporting good governance for sustainable development (SDG 16), ensuring policy coherence and mainstreaming the Agenda 2030 into both national and foreign policies.

2.4.2 Air condition development

Suspended particulate matter $PM_{2.5}$ and PM_{10} represent the main air pollutants in the Czech together with SO_2, NO_x, VOC, PAH and NH_3. Current significant sources of these emissions include generation of electricity and heating (from the perspective of SO_2 and NO_x production), transportation (producing NO_x, $PM_{2.5}$ and PM_{10}, and VOC), household heating ($PM_{2.5}$,PM_{10} and PAH) and metallurgy industry, including coking plants ($PM_{2.5,}$ PM_{10} , PAH, NO_x and SO_2). Agriculture is one of the main sources of NH_3, sectors using solvents are the main producers of VOC.

There has been a significant decrease in emissions of all main monitored polluting substances between years 2005 and 2020: The emissions of primary PM_{10} and $PM_{2.5}$ particulate matter dropped both approximately by 26%. The NO_x emissions decreased by 48.6%, SO_2 emissions by 68 %. VOC emissions dropped by 27% , CO by 16%, NH_3 by 9%.

Concerning NOx emission, positive development in terms of lowered emission burden was caused primarily by reduced emissions generated by transportation due to upgrades of the vehicle pool and emissions generated by stationary sources (energy sector).

SO_2 emissions are caused mostly by coal use in electricity and heat generation. The largest group of SO_2 emission sources is the public and industrial energy sector, which provides in 2019 for approximately 50% of emissions. A significant decline of the SO_2 emissions is happening in this sector due to decreasing emission limit values and as a result of fuel switching. Vast part of the remaining emissions (nearly 25%) is generated in the sector of domestic heating.

NO_x compounds are being discharged into air mostly by Transportation (30% in 2019), Energy and heat sector (22%) and Manufacturing industries and construction sector (12%).

VOC emissions are generated mostly by the industrial processes and solvent use with about 36% share in 2019. Heating of households generates even about 38% of VOC emissions and Transportation 6.2%. Significant producer of VOC emissions is also agricultural sector, which is responsible for approximately 14% of VOC emissions.

Argiculture is prominent source of NH_3 as it produces more than 90% of total emissions of ammonia.

Currently (according to 2020 data) limit values set for PM_{10}, $PM_{2.5}$ are being continuously exceeded in certain areas of the Czech Republic. Precursors of secondary particulate matter emitted from energy sector and industry (SO_2 and NO_x) as well as from agriculture (NH_3) are also contributing to the poor air quality. High NO_2 concentrations are problematic in certain areas in Prague and Brno due to high traffic intensity. Despite the noncompliance of the Czech Republic with the above mentioned air quality standards the overall air quality in the Czech republic is gradually improving.

At present, the Czech Republic complies with valid national emission ceilings and fulfils its national emission reduction commitments applicable from 2020, as laid down by the Directive (EU) 2016/2284 of the European Parliament and of the Council on the reduction of national emissions of certain atmospheric pollutants. For NO_X, VOC targets for 2025 have already been achieved and for SO_2 even the emission reduction target for the year 2030 has been achieved.

2.4.3 Water condition development

Similarly to air, pollution of surface water is decreasing, and there has been positive improvement in its quality. Quality is affected mostly by point sources (cities and municipalities, industrial plants and industrial cattle farming facilities), as well as area sources (farming and application of mineral fertilisers and barnyard manure and other chemical compounds, atmospheric depositions and erosion runoffs).

The number of inhabitants connected to drinking water supply systems is increasing steadily, with 94.6% of the population having access to high quality drinking water.

In long-term perspective, there has been a steady improvement in sewerage infrastructure and waste water treatment plants (WWTP). Between 2000 and 2020, the size of the sewerage network has more than doubled, the numbers of people connected to sewerage increased from 75% to 86% and the number of people connected to sewerage terminated in a WWTP rose from 64% to 83%; the ratio of treated waste water has increased slightly from 95% to 98%.

2.4.4 Urbanized landscape

Settlements in the Czech Republic are characteristically rather dispersed, there are 6 258 municipalities, mostly small with population not exceeding 500 and that makes it considerably different from other EU Member States.

During historical development, the original natural landscape has been more or less modified on the majority of the Czech territory and the natural ecosystems became artificial. In 2020, the agricultural land took up 53.253% of the Czech territory, and its area has been steadily decreasing. Forests take up 33.9534,1% and their area has been gradually increasing. The remainder of the territory are water surfaces, wetlands, built-up areas and other surfaces.

Changes commencing in 1989 are characterised primarily by the suburbanization processes. The most significant changes in the last two decades are therefore very intensive changes in functional use of suburban and urban landscapes; extensive development of commercial zones and residential districts with increased transportation demands connected with daily commuting to places of work. Suburbanization processes, and other real estate developments, take up quality crop land, limit natural diffusion of floods on floodplains and fragmentation of the landscape generally.

2.4.5 Nature

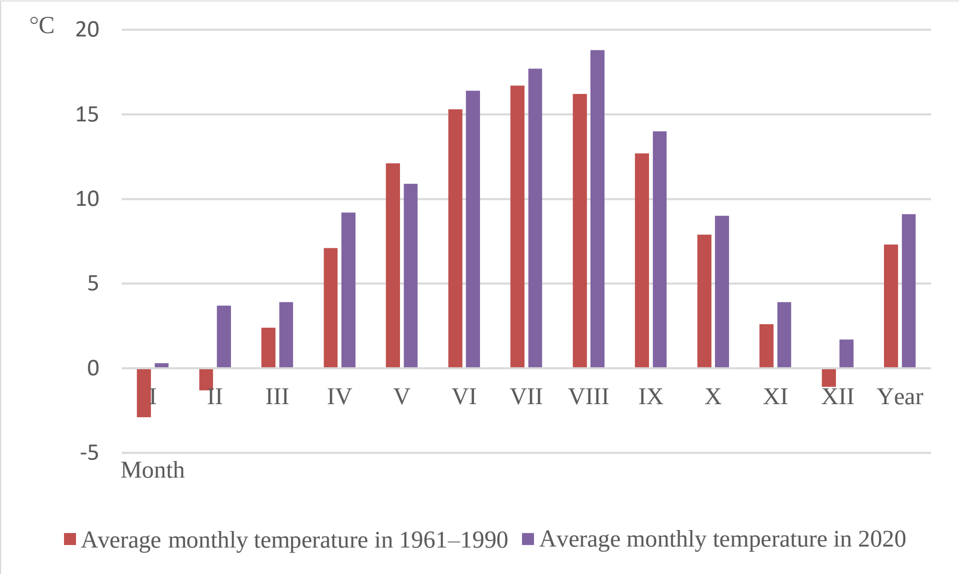
There are currently four national parks (Krkonoše (Giant Mountains), Šumava, Podyjí and České Švýcarsko (Czech Switzerland)) taking up 1 195 km^2 and 26 smaller protected landscape areas (11 435 km^2), which represent about 16% of the territory of the Czech Republic. Upon accession to the EU, the Czech Republic created the corresponding network of European system of sites of Community importance and bird areas – the so-called Natura 2000 system (comprising of 41 bird habitats and 1112 sites with European significance). The total area of the Natura 2000 network exceeds 11 115 km^2, i.e. 14% of the entire Czech territory (EU average is 18.1%). Most of the naturally significant sites are protected by a special regime pursuant to Act No. 114/1992 Coll., on protection of nature and the landscape, as amended.

2.5 Climate

The following description of the climate features is based on long-term data recorded during the previous decades and the updated National Action Plan on Adaptation to Climate Change and Climate Change Adaptation Strategy of the Czech Republic adopted by the Government in September 2021.

The Czech Republic lies within the Atlantic-continental area of the moderate climate zone of the northern hemisphere. Average annual temperature fluctuates in dependence on geographic factors between 1.1 to 9.7 °C. It is estimated that until the end of this century the annual average temperature in the Czech Republic will rise up to 2 °C. The lowest temperature averages are recorded in mountainous regions along the northern, eastern and south-western borders of the territory. The warmest regions lie in altitudes not exceeding 200 m (lowlands in southeast and along the Elbe River). Average spring and autumn temperature oscillate around 8 °C, during the summer months the temperature rises to 17 °C on average, in winter the temperature drops to about 0 °C on average. Prague represents a specific region, as within its heat island[5] the average annual temperature is higher by approximately 2 °C above the value normal for its geographic location.

Figure 2.1: Average monthly air temperature (territorial temperatures) compared to 1961–1990 in 2020



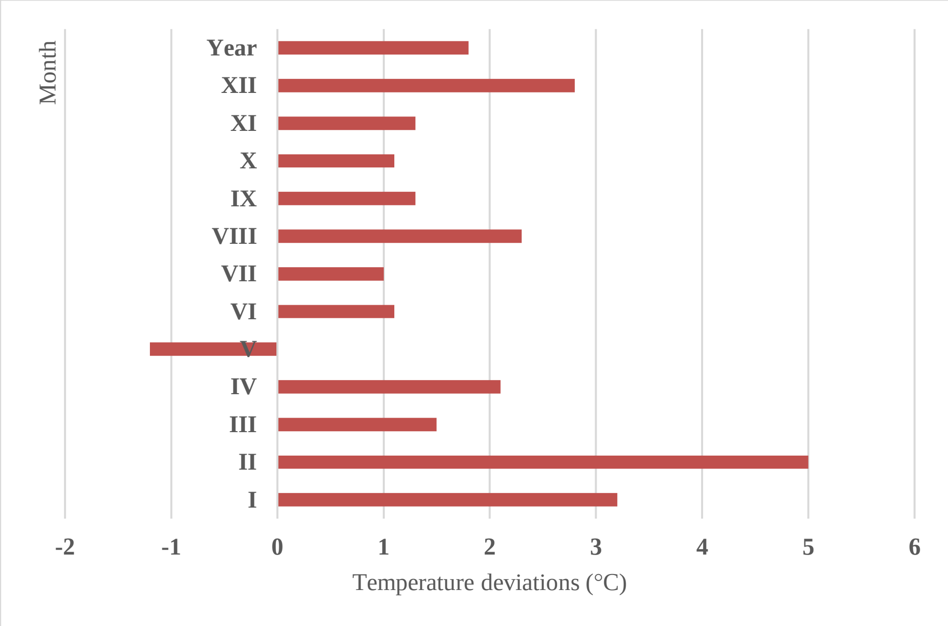
Source: CHMI

The annual course of average air temperature assumes the shape of a simple wave with the minimum in January and the maximum in July and August (Figure 2.1). Comparing temperature trends in 1961–1990 and 2020 (Figure 2.2) indicates that the average annual temperature between these two periods increased by 1.8 °C, with highest increase in February (by 5 °C); in May there has been a decrease by 1.2 °C.

During the summer and winter months the fluctuations of average temperature are more significant; in the spring and autumn they are lower. Table 2.1 gives values of these fluctuations from average temperature (°C) supplemented with changes in total monthly precipitation amounts between 1961–1990 and 2020. Increased precipitation in the summer and autumn is mostly attributed to storm rainfall. Average precipitation in 2020 is approximately 13% higher than during 1961–1990.

[5] Beranová, R., Huth, R. (2003): Prague heat island during different synoptic conditions. Meteorological Bulletin, 56, no. 5, pp 137-142, ISSN 0026-1173.

Figure 2.2: Average monthly temperature deviations between the 1961–1990 period and 2020



Source: CHMI

Table 2.1: Changes in average temperature (°C) and total precipitation amounts between the 1961–1990 and 2020

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year
Temperature (°C)	3.2	5	1.5	2.1	-1.2	1.1	1	2.3	1.3	1.1	1.3	2.8	1.8
Precipitation (mm)	-23	+40	-4	-29	-1	+68	-18	+33	+22	+50	-27	-20	+92
Precipitation (ratio)	0.45	2.05	0.9	0.38	1.01	1.80	0.77	1.42	1.42	2.19	0.44	0.58	1.13

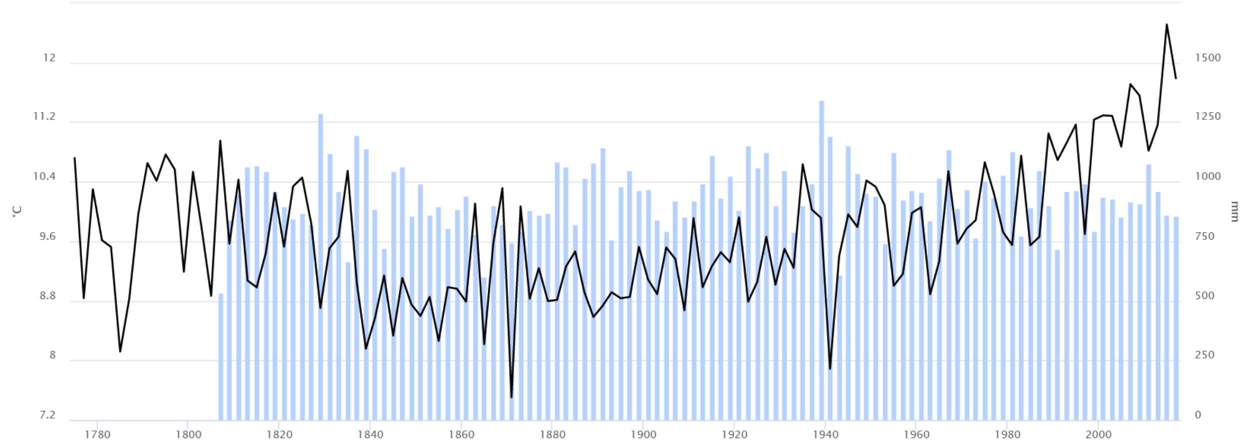
Source: CHMI

The records registered at the Prague-Klementinum[6] meteorological station, which keeps temperature records since 1775 and precipitation since 1805 (Figure 2.3), may be used to illustrate, for orientation, the long-term development of the temperature and precipitation regime in the Czech Republic. It is apparent that the end of the 18th century had been warmer and that the first half of the 19th century had been colder. From the second half of the 19th century the temperature gradually rose, the rise steadied in the mid-20th century, but temperature began rising steadily and markedly since the 80s of the 20th century again. Similar trends apply to seasonal cycles.

[6] Temperature progression can be used for an entirely demonstrable manner of detection of temperature change due to climate change only with difficulty because the station is very specific urban-type station and measured values are affected by the so-called heat island within city, which is a value proportional to the degree of urbanization and urban development. It is clear that in the period 1775–2012, the city gradually increased urbanization from a completely unknown value to the present level of around 2.0 to 2.5 °C and in no case can be this anthropogenic heat contribution filtered from the measured temperature curve. For precipitation progression, the influence of the station position in the centre of the city may be only negligible.

Year-on-year fluctuations of precipitation amounts are very high; for instance, for 2002 we record the third highest annual precipitation amount, while for 2003 the annual precipitation was second lowest in the 207 years of records. Despite that, there is an indistinctive trend of decreasing precipitation since the thirties of 20th century.

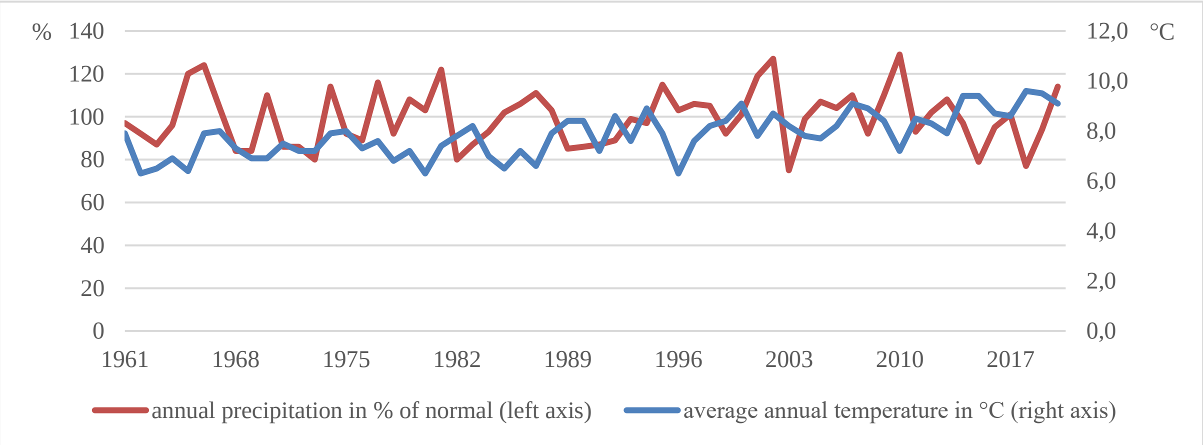
Figure 2.3: Average annual temperature between 1775 and 2019 and average annual precipitation between 1805 and 2019, Prague-Klementinum



Source: CHMI

Fluctuation of average daily temperature over the last 160 years in the Czech Republic indicates that there is an incremental growth of the temperatures; between 1861 and 1910 the average daily temperature in the Czech Republic was 9.1 °C, between 1911 and 1960 it was 9.6 °C and between 1961 and 2020 it was 10.7 °C. Regarding average daily precipitation there is a significant decrease in the last 40 years (Figure 2.4).

Figure 2.4: Average daily temperature in °C (left) and average daily precipitation in mm (right) in the last 160 years

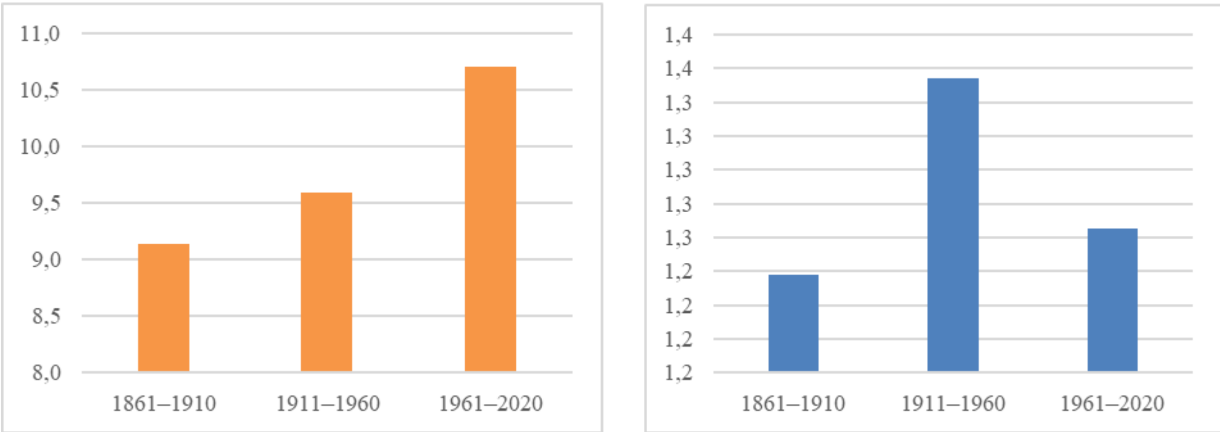


Source: CHMI

The two fundamental indicators of climate (temperature and precipitation) and their development may be described in a more precise manner using time series of territorial temperatures, respectively territorial precipitation, which are available since 1961. Territorial temperatures represent average air temperature reduced to medium altitude, considering results from the entire station network run by the CHMI, and illustrate the character of temperature regime development in the Czech Republic over the last 50 years; territorial precipitation models are constructed in a similar way.

Despite significant year-on-year changes, Figure 2.6 makes the trend of gradually increasing annual average air temperature apparent. The differences between periods of the year are not marked – higher growth trends are apparent in the summer and winter; in the spring and autumn, the average temperature growth trend is, in comparison with other seasons, lower. In the summer, Moravia heats up quicker, in the winter and in the spring Bohemia warms up quicker. The differences between Bohemia and Moravia do not exceed temperature change of more than 0.05 °C/10 years and remain almost the same in the autumn. Considering the substantial year-on-year fluctuation of precipitation amounts, similar changes are statistically entirely negligible. For instance, in 2002 and 2010 precipitation levels were the highest in the entire run of records, while in 2003 and 2018 the annual precipitation was the lowest over the same period.

Figure 2.6: Average annual territorial temperature and precipitation in the Czech Republic in 1961–2020



Source: CHMI

The number of days when maximum (TMA) or minimum (TMI) air temperature exceeded or failed to reach the determined threshold limit is a climatological characteristic used to describe thermal regime of a monitored location or territory. In order to describe the course and etremalities of the warm part of the year, we use the number of summer days (TMA ≥ 25 °C), and tropical days (TMA ≥ 30 °C) and tropical nights (TMI ≥ 20 °C). The course and etremalities of the cold part of the year is characterised by and number of frost days (TMI < 0 °C), and ice days (TMA < 0 °C) and arctic days (TMA ≤ -10 °C). In order to get bearings on the potential development of the so-called “heat waves” these statistics are being supplemented by analysis of the number of days when the TMA ≥ 35 °C.

Average numbers of days with extreme temperatures and their change between two periods of time (Table 2.2), values are rounded up to whole days) show that in the last two decades there has been an increase in average number of days with high temperature and decrease in days with low temperature in the Czech Republic, which complements the gradual growth of temperatures and growing temperature extremality. Number of summer days has increased by 43 on average, number of tropical days by 18, and conversely the number of frost days dropped by 88 on average and ice days by 32. Similar trend has been recorded with respect to tropical nights and arctic days; however, statistically significant changes are not being recorded. Numbers of days with temperatures exceeding ≥ 35 °C occur, depending on actual weather, so far only exceptionally and their changes are also statistically negligible.

Table 2.2: Changes in average number of days with extreme temperatures in 1961–1990, 2015–2020 periods

Summer days TMA ≥ 25 °C	1961–1990	33	**Frost days** TMI < 0 °C	1961–1990	120
	2015–2020	76		2015–2020	32
	Change	**43**		**Change**	-88
Tropical days TMA ≥ 30 °C	1961–1990	5	**Ice days** TMA < 0 °C	1961–1990	39
	2015–2020	23		2015–2020	7
	Change	**18**		**Change**	-32

Source: CHMI

Numbers of days with precipitation level above a certain threshold are an important characteristic illustrating precipitation amounts in a territory generally. Precipitation days with precipitation amount exceeding ≥ 5 mm and ≥ 10 mm occur in the Czech Republic during the entire course of the year and their monthly numbers correspond to the annual course of precipitation – there is more precipitation in the summer, less in the winter. Days with precipitation exceeding ≥ 20 mm occur almost exclusively in the warm parts of the year, occurrence in the cold period is extraordinary.

Table 2.3, gives average precipitation and their changes between the two monitored periods show, that there has not been any statistically significant change in the last 60 years. Primary cause of this results is that significant precipitation events with strong (often rainstorm-level) precipitation are considerably inhomogeneous due to terrain topography over time and area and cannot be always recorded within the framework of existing weather stations. Radar data however confirm that the frequency of rainstorms have grown over the last three decades.

Table 2.3: Change in average precipitation amounts (mm) in 1961–1990, 2015–2020 and 2020

		I	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**	**XI**	**XII**	**Year**
mm	2020	19	78	36	18	75	152	61	111	74	92	22	28	766
	1961–1990	42	38	40	47	74	84	79	78	52	42	49	48	674
	Change (%)	**45**	**205**	**90**	**38**	**101**	**181**	**77**	**142**	**142**	**219**	**45**	**58**	**114**
	1961–1990													674
	2015–2020													629
	Change (%)													**93**

Source: CHMI

Relative humidity, cloud amount, sunshine, snow cover and duration trends remain mutually consistent and correspond to temperature trends and their amplitudes. Winter, spring and summer are characterised by extended sunshine, lower cloud amount and lower relative humidity. Conversely, in the autumn, when temperature and daily amplitude drops, we record the opposite. Average number of days with snow cover in altitudes below 600m above sea level and in higher altitudes has dropped in the last two decades in comparison with the usual number of days in the second half of the 20th century. Snow cover maxima have decreased in lowlands and also in uplands. Similar trends are also recorded for overall new snow total precipitation.

2.6 Economy

The manufacturing industry plays important role in the Czech economy, in terms of both gross value added and employment, which is reflected by a persistent trade balance surplus. The most significant macroeconomic advantages include balanced banking system and qualified labour force. On the other hand, some improvements are needed in legal system and labour market flexibility. The Czech economy is substantially reliant on the performance of its trade partners (mostly Germany and other EU countries). The Czech economy began to utilize benefits of the common market after accession to the EU in 2004. The customs-free zone accession resulted in the unprecedented improvement in the trade balance. The foreign trade development turned into the thriving domestic figures, the employment growth reached almost 2% in 2007.

Consequently, the domestic demand and gross fixed capital formation generated the vast majority of economic growth in these years. The convergence tendency of the Czech economy was characterized by an intense appreciation of Czech koruna in 2007. After a series of years with high GDP growth the Czech economy followed the financial crisis and fell into a recession at the end of 2008. This considerable downturn was reflected by worsening all relevant economic fundamentals. Modest growth in 2010–2011 was followed by another recession in 2012. Low level of confidence affected development of domestic consumption and investment that erased positive contribution of foreign trade. In 2013 the Czech economy moved on the trajectory of renewed recovery. The increasing consumer confidence was supported by low inflation and growing employment. Positive macroeconomic development culminated in 2015, mainly due to one-off factors.

The unemployment rate has been the lowest in the whole EU since 2016. After slow rise during 2017 and 2019 Czech economy was deeply effected by the COVID-19 pandemic, as well as the whole world. In Czech Republic, like in many other EU countries, the main demand factor of the economic decrease was household consumption. That contrasts with „Great Recession“ between 2008 and 2009. The GDP in 2020 decreased by 5.6% which was the biggest fall in the history of Czech Republic. That effected also the level of employment which decreased by 1.5%, despite that, the level of unemployment stays the lowest in the EU. The GDP increase by 3.3% in 2021 indicates slow recovery.

2.6.1 Anticipated development

According to the assumption that the the pandemic restriction will not be necessary the Czech National Bank[7] predicts that inflation in the begining of 2022 will rise, overcome 9% and culminate in the first half of the year after that it will slow down gradually and in the first half of 2023 will get back close to 2% target. GDP will increase by 3%. The growth of Czech economy will be pulled by household consumption and private as well as government

[7] Czech National Bank, 2022: https://www.cnb.cz/export/sites/cnb/cs/menova-politika/.galleries/zpravy_o_menove_politice/2022/zima_2022/download/zomp_2022_zima.pdf

investments will rise. In the end of 2022 will domestic economic activity achieve pre-pandemic level. The Czech crown will be strenghtening and exchange rate will get under 24 CZK/EUR.

Table 2.4: Development in population growth and main economic indicators in 1995–2020

Year	**1995**	**2010**	**2016**	**2017**	**2018**	**2019**	**2020**
Number of inhabitans (thousand)	10 331	10 517	10 565	10 590	10 626	10 669	10 700
GDP (billion CZK)	1 596.3	3 992.9	4 796.9	5 110.7	5 409.7	5 790.3	5 694.4
GDP (PPS[a]) per capita	11 604	21 016	25 067	26 673	27 907	29 156	27 797
Average gross monthly wage of emploees in the national economy (CZK)	-	23 864	27 764	29 638	32 051	34 578	35 662
Inflation rate (%)	9.1	1.5	0.7	2.5	2.1	2.8	3.2
Price indexes in the consumer sphere, total (2015=100)	52.2	93	100.7	103.1	105.3	108.3	111.8
Direct investments (billion CZK)	-	-	-186.5	-45.9	-51	-137.1	-73.1
Foreign debt of the Czech Republic (billion CZK)	457.3	2 164.4	3 498.6	4 370.3	4 412.7	4 384.3	4 301.1
Average annual exchange rate CZK vs EUR	-	25.29	27.03	26.33	25.64	25.67	26.44
Average annual exchange rate CZK vs USD	26.54	19.11	24.43	23.38	21.73	22.93	23.19
Unemployment level (%)	4.0	7.3	4.0	2.9	2.2	2.0	2.6
Balance of foreign direct investment (billion CZK)[b]	58.9	-1 822.8	-1 304.3	-1 273.2	-1 319.9	-1 146.5	-709.2

a) PPS (Purchasing Power Standard); average purchasing power 1 PPS corresponds to average purchase power of 1 EUR in EU-27.
b) + outflow / - inflow of investment *Source: CzSO, CNB*

Table 2.5: Sources of GDP in current prices in 1995–2020 period, in milion CZK (Part 1)

Year/Sector	**Agriculture, forestry, fishery**	**Industry and mining**		**Construction**	**Trade, transport, accomodation and food service**	**Information and communication activities**
		total	**of which: manufacturing**			
1995	64 428	453 783	344 159	111 078	301 033	44 027
2002	71 569	737 129	601 325	156 527	545 504	109 835
2003	68 893	744 741	611 498	168 427	571 052	117 968
2004	74 375	853 559	700 092	180 431	586 076	125 290
2005	75 064	906 366	743 330	198 161	612 832	143 634
2006	76 442	1 008 975	821 118	203 290	660 865	160 941
2007	80 622	1 095 669	895 355	223 625	708 389	181 812
2008	77 620	1 128 200	888 059	232 531	738 629	188 822

2009	69 469	1 055 201	805 216	249 238	663 903	190 648
2010	61 514	1 069 576	836 892	254 889	677 722	185 549
2011	80 536	1 130 986	898 056	236 009	672 752	189 939
2012	92 049	1 129 128	897 263	217 037	674 971	189 499
2013	97 968	1 139 021	909 902	213 444	671 525	188 646
2014	104 883	1 248 962	1 030 576	221 617	708 829	199 234
2015	102 277	1 326 941	1 106 468	235 596	773 768	216 062
2016	100 113	1 366 832	1 152 741	235 771	799 938	228 179
2017	105 159	1 420 284	1 202 728	251 353	875 985	252 822
2018	104 766	1 445 303	1 226 882	272 646	915 962	284 123
2019	107 771	1 529 988	1 309 868	294 935	969 671	330 492
2020	109 087	1 455 861	1 247 491	295 652	907 247	344 296

Source: CzSO

Table 2.6: Sources of GDP in current prices in 1995–2020 period, in milion CZK (Part 2)

Year/Sector	**Finance and insurance**	**Real estate activities**	**Profesional, sciece, technical a administrative activities**	**Public administration and defense, education, health and social care**	**Other activities**	**Gross added value**
1995	49 112	84 268	96 227	209 206	37 183	**1 450 345**
2002	65 020	192 661	162 419	362 745	57 293	**2 460 702**
2003	86 268	201 646	168 404	390 288	63 459	**2 581 146**
2004	91 429	217 539	184 570	407 383	67 291	**2 787 943**
2005	93 045	239 467	198 243	436 081	68 660	**2 971 553**
2006	98 668	257 326	208 692	459 084	74 923	**3 209 206**
2007	125 809	276 868	236 445	486 453	79 638	**3 495 330**
2008	149 207	309 341	253 783	512 208	77 623	**3 667 964**
2009	157 226	330 172	245 667	537 604	78 931	**3 578 059**
2010	167 283	330 243	245 530	537 697	83 525	**3 613 528**
2011	166 317	329 417	239 112	532 798	91 037	**3 668 903**
2012	164 556	331 381	253 176	543 721	81 994	**3 677 512**
2013	170 714	334 226	261 664	553 795	82 012	**3 713 015**
2014	167 529	345 742	270 534	578 641	84 605	**3 930 576**
2015	177 664	356 041	288 182	599 287	89 356	**4 165 174**
2016	179 461	375 082	308 483	626 143	94 717	**4 314 719**
2017	188 073	395 036	334 297	670 028	99 583	**4 592 620**
2018	207 955	446 155	358 927	734 579	104 603	**4 875 019**
2019	211 384	484 890	381 399	805 596	115 613	**5 231 739**
2020	209 886	509 295	362 146	872 816	115 149	**5 181 435**

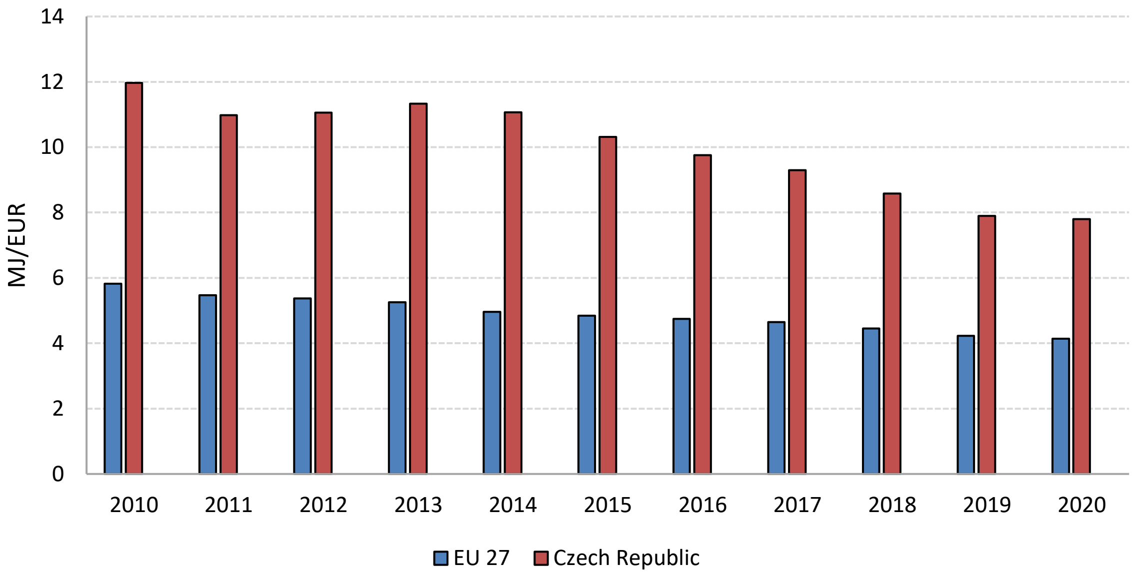
Source: CzSO

2.7 Energy and energy intensity of economy

The energy intensity of the Czech economy has been decreasing over the long term, among other also due to use of technologies that are less energy intensive, heat insulation of buildings and savings achieved by households. The Czech Republic however remains one of the countries with relatively high energy intensity per GDP unit in comparison with other EU countries (see Figure 2.7 for the comparion of energy intensity of CZ with EU27).

The **energy intensity** has been gradually decreasing. The energy intensity of the Czech economy decreased by 34.8 % between 2010 and 2020 and it reached 7.8 MJ/EUR in 2020, which is still almost double the energy intensity of EU27, which was 4.1 MJ/EUR. Nevertheless, the decrease of energy intensity have been higher compare to the the decrease on EU level, which was "only" 29.0 % in the period 2010-2020. The higher energy intensity can be partially explained by the structure of the Czech economy, which is more industrial compared to most of the other EU countries.

Figure 2.7: Energy intensity of the economy [MJ/EUR]

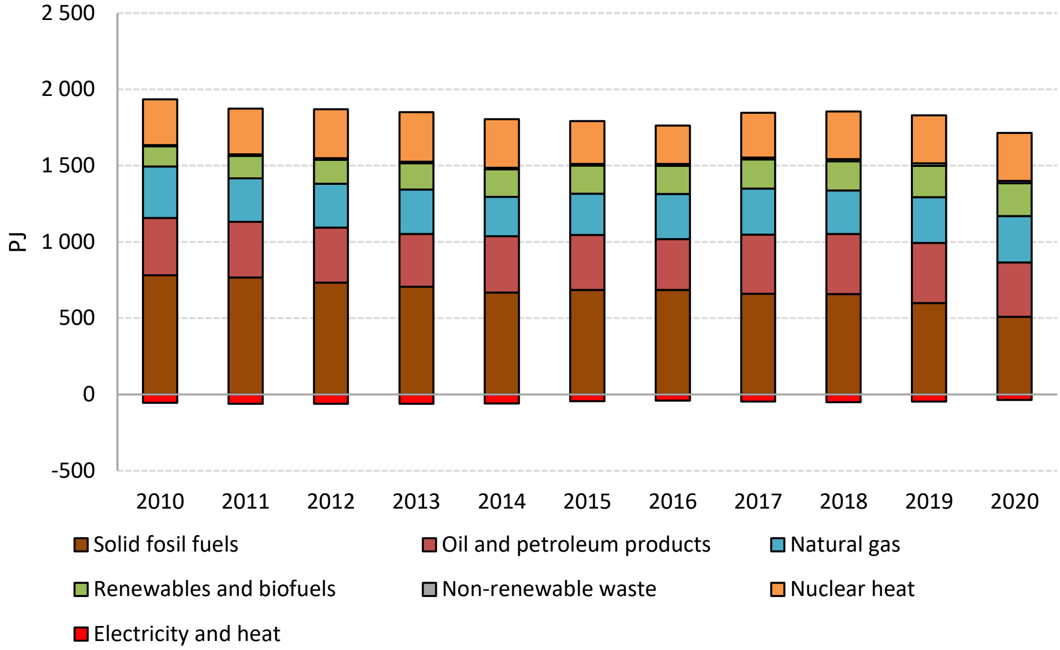


Source: Eurostat (nrg_bal_s; nama_10_gdp)

2.7.1 Development of energy consumption

The development of primary energy sources in the period 2010-2020 is shown in Figure 2.8. The trend of primary energy sources is not conclusive, its absolute value was decreasing by 2016, but after 2016 it returned to increasing trend. The share of solid fuels in primary energy consumption is gradually decreasing, driven mainly by energy efficiency measures, support for renewable sources of energy, depleting of domestic coal reserves and more stringent environmental standards.

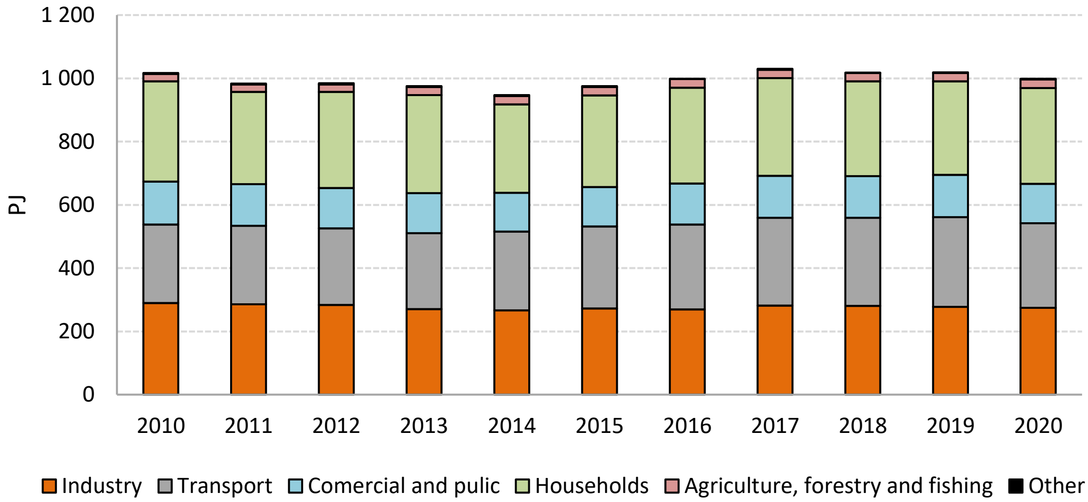
Figure 2.8: Primary energy sources according to energy sources, Czech Republic [PJ]



Source: Energy balance (MIT)

With regards to final energy consumption, there is no clear trend and it fluctuates around app. 950-1 030 PJ, reflecting number of factors mainly development of overall economy (see Figure 2.9). The biggest consumer of energy is households sector (30.3% in the year 2020), followed by industry (27.5%), transport sector (26.7%) and commercial sector (12.5%). The rest of the energy (2.9%) is consumed in agriculture, forestry and fishing and other sectors.

Figure 2.9: Final energy consumption according to sectors, Czech Republic [PJ]

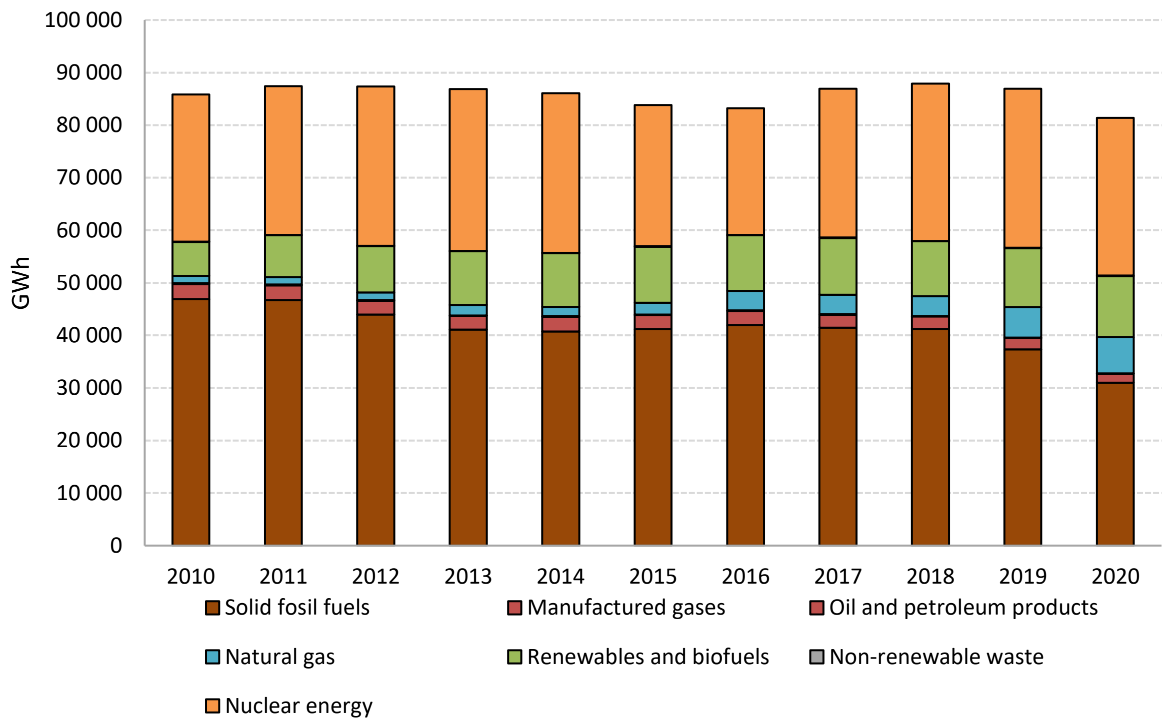


Source: Energy balance (MIT)

2.7.2 Electricity generation structure

The Czech Republic generates sufficient volume of electricity to cover its domestic demand. In the year 2020 electricity generation (on brutto basis) amounted to 81.4 TWh, which covered domestic consumtion on the level of 71.4 TWh (on brutto basis), the difference was exported (actualy 23.5 TWh were exported and 13.3 TWh was imported). The Czech Republic is thus still a major exporter of electricity, nevertheless net exports are gradually decreasing (for instance in 2012 net exports was equal to 17.1 TWh) and it is expected that due to the gradual phase-out of old power generation capacities, mainly coal fired power plants, the exported volumes of electricity will further decrease and the Czech Republic might also become net importer of electricity. More than half of the electricity production is generated in low-carbon sources, namely nuclear sources (36.9% in 2020) and renewable energy sources (14.3%). Solid fossil fuels, namely domestically extracted coal, are still important source in electricity generation (38.1%), but their role is gradually decreasing.

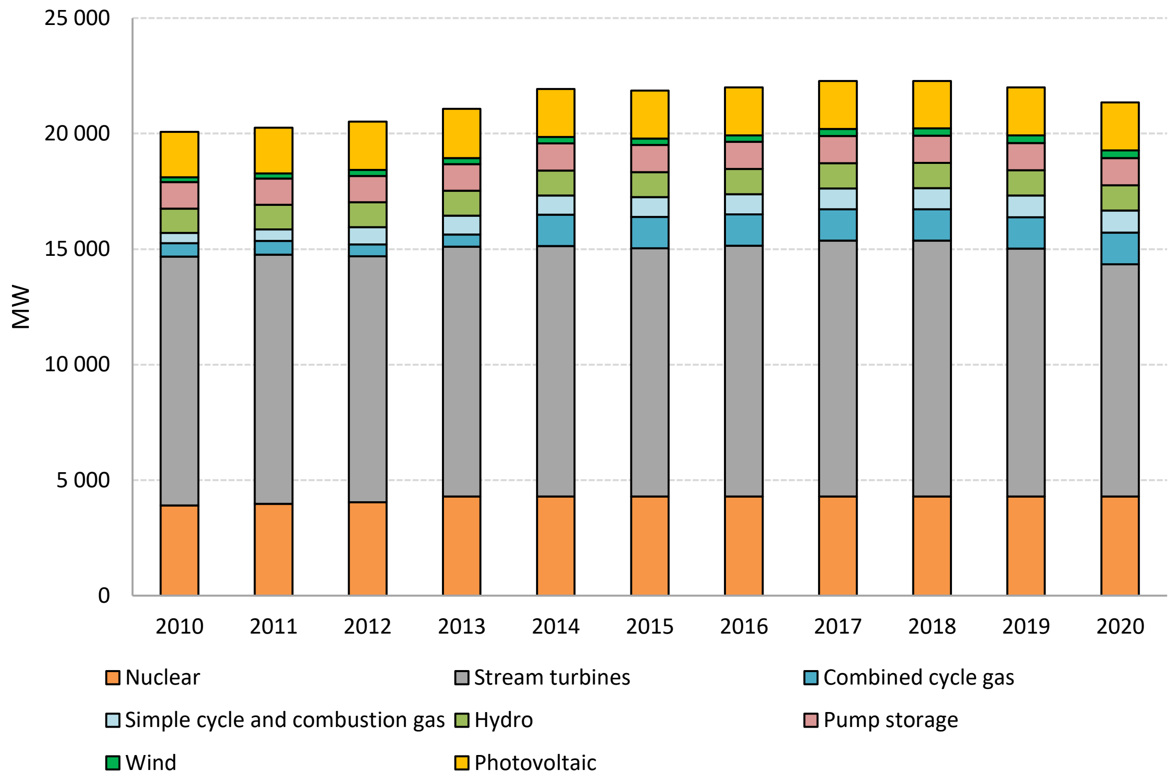
Figure 2.10: Structure of electricity generation in the Czech Republic [GWh]



Source: Energy balance (MIT)

Overall installed capacity icreased by app. 2.2 GW in the period 2010-2018, which was caused by commissioned of CCGT Počerady and coal power plan in Ledvice, development of renewables, but also for instance by uprating of current nuclear reactors (see Figure 2.11). From the year 2018 there was a slight decrease mainly due to cease of the operation of some coal power plants. Installed capacity in 2020 equelled to 21.4 GW, which covered the maximum load by great margin (the maximum load in 2020 was 11.9 GW). Technology wise, installed capacity is still dominated by steam turbines using mainly coal, but it is expected that this share will decrease.

Figure 2.11: Structure of installed capacity in the Czech Republic [MW]



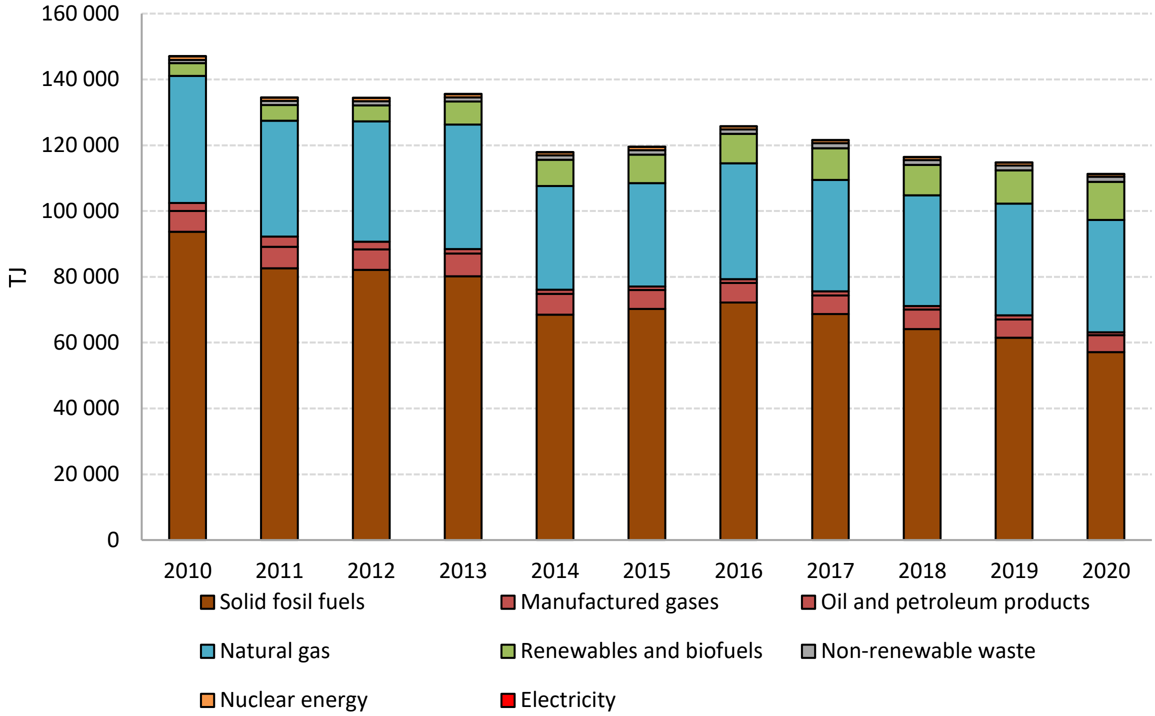
Source: ERO

2.7.3 Heat production structure

The Czech Republic has an extensive network of district heating based on centralized heat production. Centralized heating is still based predominately on fossil fuels, mainly coal, eventhough its role it gradually decreasing. More than 75% of heat is produced in combined heat and power production, which leads to savings of primary energy sources. Individual heating is dominated by natural gas, but other sources such as biomass play important role. Almost one fourth of overall heat (centralized and also individual) is generated using RES (see part devoted to RES).

The overall heat production (this included only heat generated on centralized basis, which is sold to the third parties, it does not include the heat generated on the individual basis) is decreasing on the overall basis (see Figure 2.12). In the year 2020 the heat production reached 111.2 PJ, which was 35.7 PJ lower compare to the year 2010. It is difficult to pinpoint the main reason for this decrease, but number of factors might be contributing such as increase of energy efficiency, number of heating days, switch to the individual heating etc.

Figure 2.12: Structure of heat production in the Czech Republic [TJ]



Source: Energy balance (MIT)

2.7.4 Energy and renewable energy sources

The significance of renewable energy sources (RES) in the Czech energy sector has been steadily growing. The overall share of RES in 2020 in final energy consumption (in EUROSTAT methodology) equalled 17.5%, which is 7 p.p. higher compare to 2010 (see Table 2.7). The share of RES has also been increasing in all main sectors. The share of RES in power sector in 2020 equalled to 14.8%, in transport it reached 9.4% and in heating and cooling sector it amounted to 23.5%.

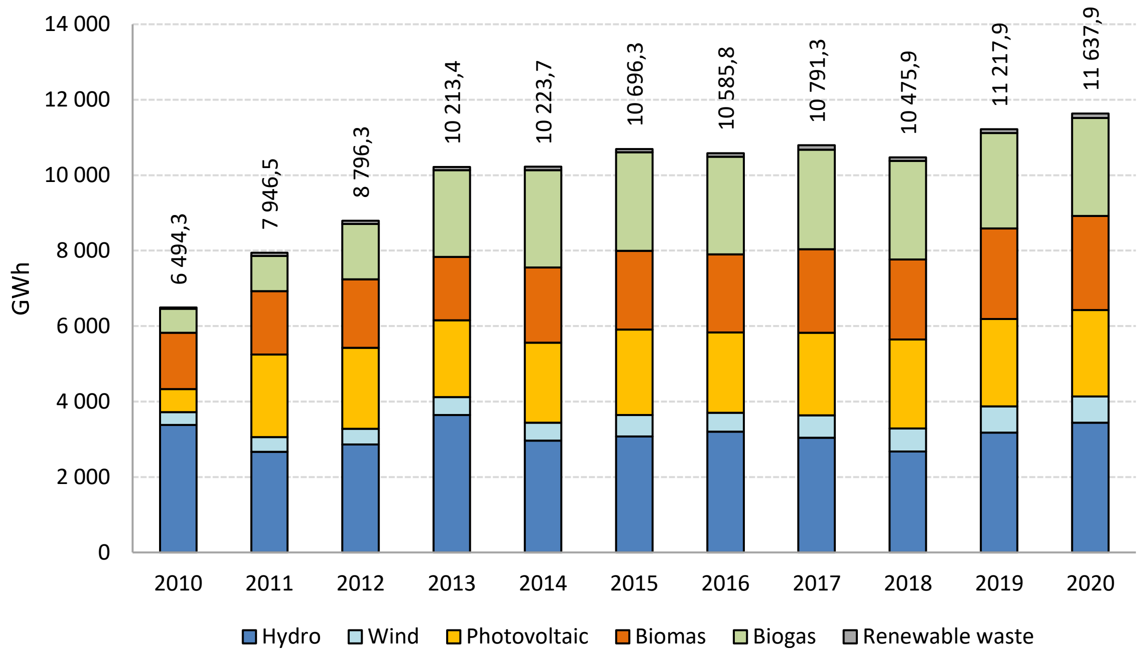
Table 2.7: Share of RES in final energy consumption (%)

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Electricity	7.5	10.6	11.7	12.8	13.9	14.1	13.6	13.7	13.7	14.0	14.8
Transport	5.2	1.3	6.2	6.4	7.0	6.5	6.5	6.6	6.6	7.8	9.4
Heating	14.1	15.4	16.2	17.7	19.5	19.8	19.9	19.7	20.6	22.6	23.5
Total	10.5	10.9	12.8	13.9	15.1	15.1	14.9	14.8	15.1	16.2	17.5

Source: MIT

In the year 2020 the generation of electricity from RES was app. 11.6 TWh, which is more than 5 TWh higher compared to the year 2010. The biggest contribution comes from bioenergy (43.8%) in the form of biogas (22.3%) and biomass (21.5%), followed by hydropower (29.5%). The other important RES are photovoltaic (19.7%), wind (6.0%) and renewable waste (1.0%).

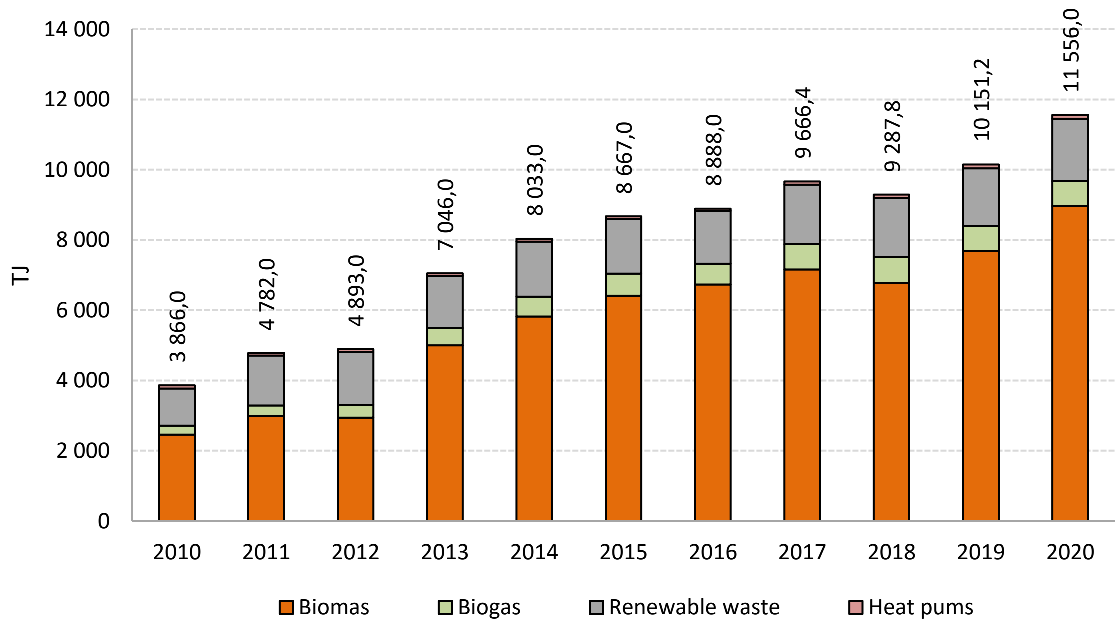
Figure 2.13: Electricity generation from RES in the Czech Republic [GWh]



Source: Energy balance (MIT)

RES also contributed to the productin of heat. In the year 2020 app. 11.5 PJ of heat came from RES (see Figure 2.14), namely from biomas (77.6%), renewable waste (15.4%), biogas (6.1.%) and heat pumps (0.9%).

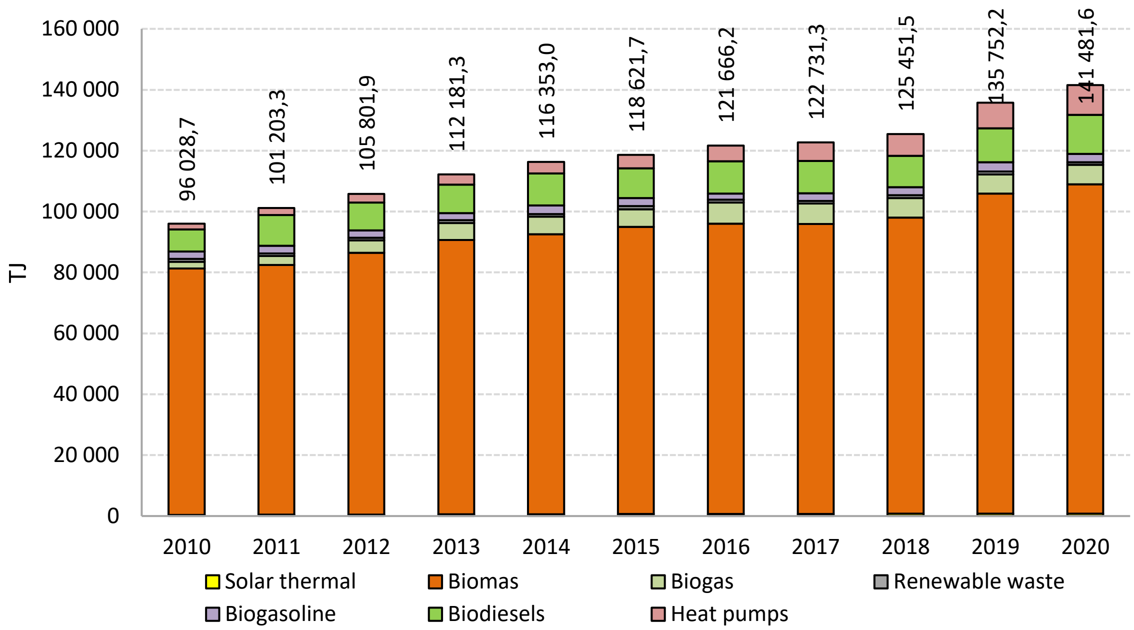
Figure 2.14: Gross heat production from RES in the Czech Republic [GJ]



Source: Energy balance (MIT)

Final energy consumption cover by RES increased by app. 45.5 PJ in 2020 compare to 2010 to the level of 141.5 PJ. More than two thirds of final energy consumption covered by RES in consumed in the from of biomas, which is used mainly for individual heating. If we take bioenergy together, so including also biogas (4.5%) and renewable gas (0.6%) it covers more than 80% of final energy consumption (81.6% in the year 2020). More than ten procent (11.0% in 2020) is covered by biofuels (biodiesel: 9.1%, biogasoline: 1.9%), which cover part of the consumtion of liquid fuels in transport. There is also growing contribution of heat pumps, which covere around 6.8% of final consumption in 2020. Solar thermal contributed by "only" 0.6%.

Figure 2.15: Final energy consumption of RES and in the Czech Republic [GJ]



Source: Energy balance (MIT)

2.8 Resources management

The Czech Republic has relatively large mineral resources potential, especially in the field of industrial minerals and construction materials deposits. Some mineral resources, for example energy reserves, have been already depleted. Surplus of cheap imported hard coal in the world market has led to suppression of hard coal mining. Lignite mining in open strip mines has considerable negative environmental impacts, but covers still approximately half of electricity production in the Czech Republic. From the perspective of sustainable development, the increased use of renewable energy and energy savings are well justified. Recycling of industrial and consumer waste and its energy recovery is still small, but increasingly an important factor. Secondary raw materials market (aluminium, steel, glass, plastics etc.) reacts sharply to the prices of primary raw materials and fossil fuels.

Mineral resource mining reached approximately 0.4% on the total GDP in 2020. The Czech economy depends on imports of a number of mineral resources, especially from the group of energy fuels (as crude oil and natural gas) or ores and metals. At present time, from the field of metals, the Czech Republic has mineral deposits of gold, tungsten and lithium, some of which can be significant in the future. Mineable reserves of lignite and hard coal are partly limited by administrative decisions, partly (in case of hard coal) by difficult situation in the world hard coal market. The country has sufficient supply of certain non-metallic and construction raw materials, with deposits sufficient for tens up to hundreds of years. The Czech Republic has raw material basis especially for development of traditional industrial sectors – glass-making (silica sand, feldspars), ceramics and porcelain (wide variety of ceramic clays, feldspars, china, kaolin) and paper-making (paper kaolin). Technical quality of cement production, lime and plaster are comparable with production in the highly developed EU countries. Former mineral deposits of natural gas and oil are used for underground storage of natural gas.

At present time, the Czech Republic mines the following mineral resources: brown coal (lignite), black coal, crude oil, natural gas, uranium, kaolin, clays, bentonite, feldspar, silica sand, limestones, diatomite, dolomites, gypsum, and wide variety of decorative stones, building stone, sand and gravel and brick-clay. In terms of volume (2015-2020), the most important is bown coal mining in open mines, which –decreased from 38 to 30 million tons annually. Black coal mining decreased from 8 to 2 million tons annually, limestone production fluctuates around 10 million tons annually as well as production of construction materials (especially exclusive building stone and sand and gravel).

2.9 Transport

The Czech Republic's central location within Europe makes it a crossroad for all kinds of transportation; at the same time, the country has one of the densest transportation infrastructures within the EU. The fundamental pillar is combination of road and railway transportation.

In terms of transportation output in personal transportation there had been a decrease in 2010 and 2012, which may had been caused by a rapid growth of consumption tax and fuel prices in this period. Another factor which contributed to decrease of personal transportation output, but also freight transport, in 2009, was economic crisis in the 2008. Individual automobile transportation recorded a steady increase in passenger transport (Table 2.9). Its decrease between years 2009 – 2012 was to certain degree a positive development, because cars contribute to the worsening of the air quality in highly urbanized areas. Biking became more popular in this period especially in smaller cities and towns, which had been greatly assisted by development of safe infrastructure. In towns with 5000 up to 50 000 inhabitants, biking-related transportation reaches 2 to 25% of transportation to and from work. Transport performance of road freight transport shows an increasing trend (Table 2.10). The performance and also the number of passengers have increased in the passenger railway transport since the significant decline in 2009. Values of transport performance of the freight railway transport show variable trend. Railway transportation in 1990 processed almost 70% of the total freight transportation in the Czech Republic, while today it is only approximately 21%. The vast majority of freight in the Czech Republic is transported by road. This is a problem particularly in terms of the high intensity of freight transport on the main routes, increased air pollution and degradation of transport network. Data for air transportation show sharp decrease in 2020 because of the COVID-19 pandemic. 30% decrease in public transport output was also observed.

Table 2.9: Personal transportation output in 1990 – 2020 (billion person-kilometres)

	1990	1995	2000	2005	2010	2015	2020
Road – on own account	39.90	54.50	63.94	68.64	63.57	69.71	68.93
Road – public	12.34	7.67	9.35	8.61	10.34	9.99	9.27
Railway transportation	13.36	8.01	7.30	6.66	6.59	8.30	6.65
Air transportation	2.18	3.03	5.86	9.74	10.90	9.70	1.86
Water-borne transportation	0.00	0.01	0.01	0.02	0.01	0.01	0.01
Total	67.78	73.22	86.45	93.66	91.41	97.71	86.72

Source: MoT

Table 2.10: Transport output – freight 1990 – 2020 (billion tkm)

	1990	1995	2000	2005	2010	2015	2020
Road	16.82	32.50	39.04	43.45	51.83	57.20	56.09
Railway	41.14	25.50	17.50	14.87	13.77	15.26	15.25
Air transportation	0.06	0.03	0.04	0.05	0.02	0.03	0.01
Water transportation	1.41	1.23	0.77	0.78	0.68	0.59	0.51
Total	59.43	59.26	57.34	59.14	66.31	73.08	71.86

Source: MoT

Table 2.11: Number of persons transported by air 2000 – 2020 (thousand)

Indicator	2000	2005	2010	2015	2016	2017	2018	2019	2020
Total number of persons transported (thousand)[2)]	3 483	6 330	7 466	5 393	6 000	6 657	7 234	6 922	1 117

[2)] Only Czech commercial operators *Source: CzSO*

The railway network density is comparatively high (12.1 km of railways per 100 km^2). The railway infrastructure however required substantial upgrade, which extends for several years. Modernization of the first transit corridor started in 1993 and it has been mostly completed except the 10 km of track and some major railway junctions. Modernization of the second transit corridor started in 1997 and it was completed except railway junctions Přerov and Ostrava. Modernization of third and fourth transit corridor started shortly after year 2000 and 2005. Works on these corridors still continues and modernization will bring an increase in speed of train sets up to 160 km per hour. Currently, debate on high-speed lines, which could be built in the Czech Republic is in progress. Start of the construction is not expected before the year 2030.

The road network also required modernization and construction of new roads and motorways. In 2015 the road infrastructure density was 70.67 km/100 km^2. In 2012 the modernization of the busiest highway D1 has begun. Modernization consists of extension of the width of the road from 26.5 m to 28 m for the possibility of operation in mode 2 + 2 lanes in one direction during one lane closures. Total renovation of the repaired section of highway is included in modernization of D1. Construction of new highways and motorways is in progress. Length of highways increased from 734 km in 2010 to 776 km in 2015 and length of motorways increased from 422 km in 2010 to 459 km in 2015. Technical neglect of road infrastructure was a permanent issue. This technical neglect was mostly caused by transport failures, insufficient capacity, quality and also inadequate parameters. Currently the quality of roads is gradually improving thanks to a continuous increase of investment in transport infrastructure.

In 1990, the transportation-generated emissions amounted to mere 5.7% of total CO_2 emissions in the Czech Republic. Until 2020 this value raised to 15.7%. Greenhouse gasses (CO_2, N_2O and CH_4) show increasing trend from 1990 to present. For the first time the values of these emissions decreased between years 2009 – 2013 due to the economic crisis and reduction of fuel consumption. This trend positively affected the emission load from transport to the environment.

Table 2.12 gives an overview of the number of vehicles in the Czech Republic between 1990 and 2020. Vehicle numbers almost tripled over the last 30 years and reached a total of more than 10 million in 2020 – which is 572.5 passenger cars per 1000 inhabitants in 2020.

Table 2.12: Number of motor vehicles in the Czech Republic 1990 – 2020 (in thousands)

	1990	**2000**	**2010**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Single-track	1 172	748	924	1 046	1 075	1 102	1 132	1 163	1 196
Personal cars	2 411	3 439	4 496	5 115	5 308	5 538	5 748	5 925	6 049
Trucks	156	276	585	647	668	689	706	720	728
Buses	26	18	20	20	20	21	21	21	19
Total	3 765	4 481	6 025	8 843	9 087	9 367	9 625	9 848	10 012

Source: MoT, TRC

Despite continuous improvements in the structure of vehicle fleet the average age of all categories of vehicles in the Czech Republic remains high and continues to increase. Vehicles older than 10 years represent 62.31% of vehicle fleet in Czech Republic to date. Number of cars complying with higher EURO standard has been growing same as the number of motor vehicles operated on alternative fuels.

Table 2.13 provides data on static structure of personal cars according to vehicle age. In 2020 number of passenger cars older the 10 years was 3.8 million cars, in 2010 it was 2.7 million passenger cars. Distribution of passenger cars in static composition of vehicle fleet according to age in 2020 is following: 21.6% cars 0-5 year old, 16.1% cars 6-10 year old and 62.3% cars more than 10 years old. Data on dynamic structure, which are collected every five years, indicate significantly higher use of newer cars compared to older cars, which improves real environmental parameters of the vehicle fleet as a whole. In 2010, distribution of personal cars according to age was the following: 31.10% of cars fell within 0-5 years of age; 30.14% of vehicles were 6-10 years old and 38.76% of cars were 10 years old or older. The average age of cars is still rising in recent years and has reached 15.6 years.

Table 2.13: Share of personal cars registered in the Czech Republic according to their age

	2000	2005	2010	2015	2020
0-5 years	17.55	17.81	18.09	23.64	21.56
6-10 years	23.15	22.17	21.51	22.20	16.13
10 years or older	59.31	60.02	60.40	54.16	62.31

Source: TRC, MoT

Table 2.14 gives fuel consumption in individual transport sectors. Fuel consumption data shows a downward trend in consumption of road petrol. There was recorded a decrease in consumption of road diesel between years 2008 – 2010 and afterwards an increasing trend has appeared again related to the increasing number of diesel vehicles.

Table 2.14: Fuel consumption by sector (TJ)

	2000	2005	2010	2015	2020
road - petrol	79 855	88 239	77 634	65 188	59 821
road - diesel	74 323	135 003	142 061	163 142	171 360
road - LPG	2 849	3 216	3 538	4 503	3 400
road - CNG	97	146	343	1 528	3 171
road - biodiesel	2 590	111	7 252	9 768	12 839
road - bio ethanol	-	-	2 430	2 646	2 754
railway - diesel	4 440	3 848	3 959	3 607	3 136
water-borne - diesel	213	209	172	129	172
air - AVGAS	131	88	88	131	88
air - kerosene	8 256	13 610	13 423	12 427	4 850

Source: CzSO

Table 2.15 demonstrates that vehicles utilising alternative fuels and drives still represent only a very small fraction of the personal vehicle fleet, with LPG being the most commonly used alternative fuel. However, there has been a significant increase in the electric vehicles in the recent years with electric vehicles representing 2.58% on newly registerd cars in 2020.

Table 2.15: Fuel used in personal cars

	2000	2005	2010	2015	2020
Petrol	3 048 524	3 233 983	3 285 189	3 292 863	3 515 604
Diesel	383 179	718 412	1 206 387	1 807 953	2 388 353
LPG	20	17	10	56	106 978
CNG and other	10	10	15	713	14 161
Electric vehicle	7 137	5 658	4 631	13 731	24 159

Source: MoT

The financial crisis in the yars after 2008 influenced decrease in industrial output as well as transport (freight) in 2009 (see Table 2.16). The value of transport performance in freight transportation in 2009 (58.36 bill. tkm) had reached second lowest level since 2001 (57.87 bill.

tkm). Lowest level since 2001 (57.88 bill. tkm) was reached in 2019 due to the COVID-19 pandemic.

Table 2.16: GDP development and development of transportation output/freight

	1990	1995	2000	2005	2010	2015	2020
GDP (billion CZK)	-	-	2 372.6	3 258.0	3 953.7	4 625.4	5 709.1
Transportation output / freight (bill. tkm)	59.43	59.26	57.34	59.14	66.30	76.61	73.52

Source: MoT and TRC

The financial crisis also caused reduction in investment directed into development of transportation network in the Czech Republic. The largest investment was directed to transportation in 2008, amounting to nearly 83 billion CZK. The volume of investment in infrastructure in 2013 has been the lowest in the last 10 years and amounted to approximately 27 billion CZK. Total investment for transport infrastructure has been increasing recently and reached more than 80 billion CZK in 2020.

Table 2.17: Total investment into transportation infrastructure (millions CZK)

Type of infrastructure	2000	2005	2010	2015	2020
Railway	13 200	14 428	14 245	31 785	29 718
Road[1)]	10 988	42 137	43 494	24 156	43 410
National water courses	402	303	1 462	413	1 467
Air transportation	993	7 045	2 059	993	5 330
Pipelines	399	164	231	155	144
Total	**25 982**	**64 077**	**61 491**	**57 502**	**80 069**

In 2021 the government has adopted a new *Transport Policy of the Czech Republic for 2021 – 2027 with an Outlook until 2050*, superseding the previous Transport Policy of the Czech Republic for 2014 – 2020, adopted in 2013. The document identifies main challenges for the transport sector and proposes measures to address them. There is a strong focus on the issues of the decarbonisation of transport and elimination of its dependence on the consumption of hydrocarbon fuels. The transition towards low-emission and zero-emission vehicles should be accompanied by a significant shift in the modal split as can be seen in the following Tables 2.18 and 2.19.

Table 2.18: Estimated modal split and GHG emissions in case of non-fulfilment of the Transport Policy and related processes, concepts and strategies

Passenger transport volumes [mil. pkm]		2019	2020	2021	2022	2023	2024	2025	2030	2035	2050
Rail transport	mil. pkm	11,191.3	11,918.9	12,431.0	12,447.3	12,187.0	11,862.9	11,438.0	10,771.0	10,112.0	8,730.0
Bus transport	mil. pkm	10,561.0	10,579.0	10,808.0	10,037.0	9,768.0	9,463.0	9,325.0	9,260.0	8,925.6	8,103.6
Air transport	mil. pkm	11,942.3	12,246.3	12,920.0	13,312.0	13,681.0	14,012.0	14,387.0	15,537.0	15,962.8	16,844.0
Inland waterway tr.	mil. pkm	13.4	13.9	14.2	14.4	14.7	15.1	15.2	15.3	15.4	16.6
Public transport	mil. pkm	18,205.0	18,438.4	18,696.7	18,923.6	18,825.2	18,822.4	19,643.3	19,579.0	18,513.0	17,457.9
trams	mil. pkm	4,404.7	4,420.0	4,447.0	4,461.0	4,450.1	4,438.1	4,401.3	4,191.0	3,905.0	3,902.2
trolleybuses	mil. pkm	862.0	858.0	853.0	847.6	843.1	841.3	838.0	827.0	819.0	809.0
Metro	mil. pkm	6,558.3	6,631.4	6,765.7	6,882.0	6,902.0	6,941.0	7,920.0	8,171.0	7,471.0	7,340.7
buses	mil. pkm	6,380.0	6,529.0	6,631.0	6,733.0	6,630.0	6,602.0	6,484.0	6,390.0	6,318.0	5,406.0
Road transport	mil. pkm	79,050.0	80,200.0	81,900.0	84,002.0	85,826.0	86,214.0	87,100.0	89,732.0	93,167.0	100,463.0
Total	mil. pkm	130,963.0	133,396.5	136,769.9	138,736.3	140,301.9	140,389.4	141,908.5	144,894.3	146,695.8	151,615.0

Freight transport volumes [mil. tkm]		2019	2020	2021	2022	2023	2024	2025	2030	2035	2050
Rail transport	mil. tkm	16,510.3	16,566.6	16,637.6	16,999.0	16,870.6	16,553.0	16,323.0	15,087.0	14,128.2	13,730.8
Road transport	mil. tkm	35,733.5	34,312.0	33,756.0	33,956.0	33,988.0	34,141.0	34,720.1	41,485.0	44,936.7	55,083.3
Inland waterway tr.	mil. tkm	559.4	592.0	637.6	665.5	693.1	730.8	758.8	864.8	944.5	991.3
Air transport	mil. tkm	21.770	24.569	29.392	32.575	33.115	34.238	34.542	35.631	36.925	40.282
Oil pipelines											
Total	mil. tkm	17,091.5	51,495.2	51,060.6	51,653.1	51,584.8	51,459.0	51,836.4	57,472.4	60,046.3	69,845.7

Carbon dioxide (CO_2) emissions

		2019	2020	2021	2022	2023	2024	2025	2030	2035	2050
Total transport	th. tonnes	20,929	21,021	20,150	21,310	19,510	19,730	20,082	21,390	22,930	25,232

Source: Transport Policy of the Czech Republic, MoT

Table 2.19: Estimated modal split and GHG emissions from transport in the case of fulfilment of the Transport Policy and related processes, concepts and strategies

Passenger transport volumes [mil. pkm]		2019	2020	2021	2022	2023	2024	2025	2030	2035	2050
Rail transport	mil. pkm	11,191.3	12,117.9	13,112.0	13,105.3	13,957.0	14,815.9	15,662.0	18,172.0	21,512.0	25,320.0
Bus transport	mil. pkm	10,561,0	10,579.0	10,808.0	11,437.0	12,168.0	12,663.0	13,205.0	15,809.0	17,213.6	19,503.6
Air transport	mil. pkm	11,942.3	12,246.3	12,920.0	13,312.0	13,681.0	14,012.0	14,387.0	15,537.0	15,962.8	16,844.0
Inland waterway tr.	mil. pkm	13.4	13.9	14.2	14.4	14.7	15.1	15.2	15.3	15.4	16.6
Public transport	mil. pkm	18,205.0	18,478.4	18,796.7	19,053.6	19,447.2	20,663.4	21,602.3	23,581.0	24,975.0	27,781.9
trams	mil. pkm	4,404.7	4,460.0	4,547.0	4,591.0	4,760.1	4,898.1	5,102.3	5,791.0	5,995.0	6711,2
trolleybuses	mil. pkm	862.0	858.0	853.0	847.6	856.1	865.3	874.0	929.0	1,100.0	1,270.0
Metro	mil. pkm	6,558.3	6,631.4	6,765.7	6,882.0	6,941.0	7,920.0	8,520.0	9,171.0	9,771.0	10,840.7
buses	mil. pkm	6,380.0	6,529.0	6,631.0	6,733.0	6,890.0	6,980.0	7,106.0	7,690.0	8,109.0	8,960.0
Road transport	mil. pkm	79,050.0	80,200.0	81,900.0	82,002.0	82,226.0	82,724.0	82,900.0	81,732.0	80,167.0	78,463.0
Total	mil. pkm	130,963.0	133,635.5	137,550.9	138,924.3	141,493.9	144,893.4	147,771.5	154,846.3	159,845.8	167,929.0

Freight transport volumes [mil. tkm]		2019	2020	2021	2022	2023	2024	2025	2030	2035	2050
Rail transport	mil. tkm	16,510.3	16,636.6	16,787.6	17,025.0	17,470.6	17,853.0	18,223.0	20,587.0	21,103.2	23,730.8
Road transport	mil. tkm	35,733.5	34,312.0	33,756.0	33,156.0	32,631.0	32,141.0	32,520.1	32,485.0	32,936.7	31,083.3
Inland waterway tr.	mil. tkm	559.4	592.0	637.6	665.5	693.1	730.8	758.8	864.8	944.5	991.3
Air transport	mil. tkm	21.770	24.569	29.392	32.575	33.115	34.238	34.542	35.631	36.925	40.282
Oil pipelines	mil. tkm										
Total	mil. tkm	52,825.0	51,565.2	51,210.6	50,879.1	50,827.8	50,759.0	51,536.4	53,972.4	55,021.3	55,845.7

Carbon dioxide (CO_2) emissions

		2019	2020	2021	2022	2023	2024	2025	2030	2035	2050
Total transport	th.	20,929	20,821	20,130	19,830	19,650	19,430	19,082	17,990	16,250	14,232

Source: Transport Policy of the Czech Republic, MoT

In 2013, *the National Strategy for Development of Bicycle Transportation of the Czech Republic 2013–2020* has been also adopted, updating the previous strategy for 2004–2011. The main objective of the strategy is to support cycling so that it becomes a fully-fledged form of transportation supplementing other forms of transportation. This strategy aimed to increase the contribution of cycling on the total transportation output to 10% by 2020 (on average for the entire Czech Republic).

In November 2015, the Czech Government approved *the National Action Plan for Clean Mobility*. The Action Plan develops an alternative fuel infrastructure - electromobility and natural gas (and partly also hydrogen). The update of the document was approved in 2020, taking into account new emission standards for vehicles and the 14% target for renewable fuels in transport.

The Czech Republic is a member of the International Civil Aviation Organization (ICAO). Regarding ICAO, measures to limit or reduce emissions of greenhouse gases from aviation bunker fuels are implemented within the EU ETS system (for more details refer to Chapter 4.4.1). In 2016 the Government of the Czech Republic approved the Conception of the Aviation transport for 2016 – 2020. The document is a strategy for achieving of goals of the Transport Policy of the Czech Republic for 2014 – 2020 with the Prospect of 2050. In chapter “Environmental Protection” the document deals with reducing of the impact of aviation on the environment in the area of noise and emissions.

The Czech Republic is a member of the International Maritime Organization (IMO). As regards the IMO, the Czech Republic doesn´t have any emissions of greenhouse gases from marine bunker fuels. However, a monitoring, reporting and verification system of marine emissions in in place in the EU and integration of maritime transport in the EU ETS is currently under discussion. The EU is active within both ICAO and IMO and strives to reach an agreement on the establishment of a market-based measure to limit or reduce emissions of greenhouse gases from aviation and marine bunker fuels.

2.10 Industrial production

Industry in the Czech Republic generates 31% of the GDP in 2020 and therefore it is one of the decisive sources of economy**.** In environmental terms, it is also a considerable producer of a wide spectrum of pollutants and waste as well as consumer of non-renewable sources of energy and raw materials. This sector has a huge impact on environment, especially in the areas where large industrial complexes are concentrated emitting large volumes of pollutants (Moravian-Silesian Region, Usti Region and Central Bohemian Regions). Relation between industry and the environment is best demonstrated by development in industrial production (according to its indexes) with development of energy intensity of industry, pollutant emissions and emission of greenhouse gases, waste and expenses directed to ecologization of production. The objective is environmental stability, which means ensuring satisfactory quality of the environment in the Czech Republic as well as limiting negative impact outside its borders.

Regardless of slight fluctuations in industrial production, the trend since 2000 has been growing. So far, industrial production in the Czech Republic has grown far faster in comparison with EU-27. Only since 2008 it had begun to stagnate and decrease in connection with global economic crisis, which had only became fully apparent year later.

The whole period 2011–2016 was influenced by a gradual decline of mining and quarrying sector and moderate decreases in the section of electricity, gas, steam and air conditioning supply (see Table 2.23).

In terms of industry's impact on the environment, there is an apparent connection between structural changes in industry, changes in production technologies and the condition of the environment generally. In the manufacturing industry, there had been large structural changes between 2000 and 2008, resulting in "lighter" production structure, i.e. growth in sectors producing technologically more demanding products with higher added value using less energy and producing fewer emissions (cars, electronics, computer technologies). Practically all sectors underwent technological innovation, especially car production, electronics, optics as well as restructured metallurgy. Drop in industrial production following 2008 economic crisis and beyond had positive impact on emissions of pollutants and on the environment, as the industrial sector produced fever emissions.

The emission production is not evenly distributed among individual sectors; the most intensive sectors are steel and metal works, refineries, cement and lime production. In a number of sectors, notably in paper and cellulose manufacture, glass-making, ceramics and chemical production and industrial energy generation (production of technological steam and electricity for own consumption) there has been a stabilization of emissions or even reduction. Industrial technologies, emitting large volumes of greenhouse gases, are covered by EU ETS.

Emissions generated by the industry may be divided into 2 groups – emissions from industrial energy generation involve mostly NO_x and SO_2 as well as CO, where steel works in Ostrava and Třinec produce vast majority thereof. Industrial processes without combustion are specific according to production types and have varying emission levels burdening the environment. In 2008–2009, emissions were favourably affected by economic crisis and therefore there had been a temporary drop in all types of emissions and the COVID-19 pandemic had later similar effects. In 2010, the recovery of the industry affected emissions in this sector, and some emissions increased. In 2020, the total emissions from industrial sector have decreased along with the falling curve of industrial production, for most of the monitored pollutants. The sole exceptions were SOx emissions, where there was a year-on-year increase. All other monitored compounds demonstrated decrease: $PM_{2.5}$ by 9.9%, PM_{10} by 13.6%, NO_x by 6.0% and NMVOC by 19.3%.

Energy intensity of the industry has been falling considerably. While in 2010 the energy intensity of the industrial sector reached 230.3 MJ/thousand CZK, in 2020 this value was only 192.7 MJ/thousand. This trend is favourable for the environment, as higher energy consumption means increased burden on the environment during its production. In 2020, there was a 2.1% year-on-year decrease of GVA in industrial sector and there has been a decrease in energy consumption by 0.9%. Introduction of new technologies, best available techniques (BATs) and measures leading to energy savings drove the decrease of energy intensity in industry.

From the perspective of investment in the industrial sector, most of the investment went to protection of the environment in the manufacturing industry. In 2021, the investment into the protection of the environment reached 4.6 billion CZK, with 1.9 billion CZK invested into the protection of air and climate.[8]

Table 2.20: Index of industrial production according to sectors (year-on-year index, previous year=100)

Selected sections/divisions	**Index of industrial production**				
	2015	2017	2018	2019	2020
Industry, total	104.3	106.5	103.0	99.8	92.8
Mining and quarrying	97.4	98.0	99.3	93.6	83.4
Manufacturing	105.5	106.9	103.3	100.0	93.0
Manufacture of paper and paper products	106.5	103.4	105.8	103.4	103.9
Manufacture of food products	104.6	101.2	103.7	101.4	100.6
Manufacture of chemicals and chemical products	95.5	119.0	100.9	97.3	96.0
Manufacture of rubber and plastic products	107.2	108.0	100.3	101.0	90.7
Manufacture of basic metals	98.6	99.1	102.8	94.0	92.9
Manufacture of machinery and equipment n.e.c.	102.6	108.8	101.7	99.4	87.6
Manufacture of computer, electronic and optical products	100.9	111.4	111.3	92.3	97.1
Manufacture of motor vehicles, trailers and semi-trailers	112.1	109.6	102.3	100.2	88.1
Manufacture of other transport equipment	105.3	90.6	110.9	98.5	95.5

[8] https://www.czso.cz/csu/czso/vydaje-na-ochranu-zivotniho-prostredi-2021

Other manufacturing	112.3	100.2	108.6	100.9	102.3
Electricity, gas, steam and air conditioning supply	97.3	104.7	101.4	99.6	93.7

Source: CzSO

Research, development and innovations

Situation in the research and development sector (R&D) can be characterized by relatively low total expenditures on R&D on the total GDP. The long-term trend with respect to R&D expenditures in the Czech Republic, as calculated in regular prices, has been growing (with the exception of 2016, which demonstrated a slight decrease). Despite this trend, the total R&D expenditures in the Czech Republic remains below the usual R&D levels in the developed EU countries, which contribute about 2 – 3% of their GDP to research and development. In the 2021 the share reached 2% GDP for the first time.

Table 2.21: Overall expenditures for research and development in the Czech Republic

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Share on GDP (%)	1.33	1.54	1.77	1.88	1.96	1.92	1.67	1.77	1.90	1.93	1.99	2.00
billion CZK	53.1	62.8	72.4	77.9	85.1	88.7	80.1	90.4	102.8	111.6	113.4	121.9

Source: CzSO 2022, Annual statistical survey - Research and development VTR 5-01

The main sources of R&D expenditures in 2021 have been the increase of investment from domestic private commercial sources and investment from public domestic and foreign sources, and furthermore since 2011, there has been a considerable increase in the support from the EU structural funds on R&D financing.

In 2021, 59.7% of total research and development expenditures came from private (domestic and foreign) sources. The contributions coming from private sources have been steadily growing. Share of university research on total R&D expenditures gradually remains aroud 20% and the share of public research decreased to 16.7% in 2021.

A low level of cooperation between private and public research institutions remains an issue.

2.11 Waste

2.11.1 Strategies and legislation

The fundamental rules for waste management are defined by Act No. 541/2020 Coll., on Waste (Waste Act), and Act No. 542/2020 Coll. on End-of-Life Products and and Act No. 477/2001 Coll. on Packaging, as amended. A new waste legislation (Act on Waste, new Act on End-of-Life Products and amendment to the Act on Packaging) was adopted in 2020 and came into force on 1 January 2021.

The Czech Republic makes substantial steps for improvement of waste management performance in line with obligatory European waste hierarchy and towards transition to a circular economy. Measures introduced in the new Waste Act lead explicitly to support of waste recycling and recovery (targets for separate collection and recycling of municipal waste by 2025, 2030 and 2035, landfill ban of recyclable and recoverable waste from 2030, target to landfill a maximum of 10% of municipal waste by 2035, gradual increase of the landfill fee) and the diversion of recyclable and recoverable waste from landfills.

Ministry of the Environment also prepared new Act on the reduction of the impact of certain plastic products on the environment which will fully implement Directive (EU) 2019/904 of the European Parliament and of the Council on the reduction of the impact of certain plastic products on the environment and which will introduce further measures that will lead to the development of circular economy in the Czech Republic. The Act should be adopted by the end of 2022.

In December 2021 a Strategic Framework for transition of the Czech Republic to a circular economy by 2040 was approved by the Czech government. The purpose of the The Strategic Framework is to set the further direction of the development of the circular economy in the Czech Republic until 2040. It defines 10 priority areas (products and design; industry, raw materials, construction, energy; bioeconomics and food; consumption and consumers; waste management; water; research, development and innovation; education and knowledge; economic instruments; circular cities and infrastructure) of the Czech Republic in the field of circular economy, formulates individual goals within these priorities and determines measures and tools for achieving the goals.

The State Environmental Policy of the Czech Republic 2030 with outlook to 2050 includes the following specific objectives for the transition to circular economy:

- material intensity of economy is decreasing
- waste prevention efforts are maximised
- waste management hierarchy is fully observed

The Government of the Czech Republic adopted a new Waste Management Plan (WMP CR) for 2015 – 2024 on 22nd December 2014. The binding part of WMP CR is published by the mandatory Government regulation and therefore is mandatory for all regional WMPs. This ensures consistency between national WMP CR and each individual regional WMPs. An update of the WMP CR was adopted in May 2022.

The updated WMP CR contains all the targets arising from the EU waste legislation revised in 2018 (targets for recycling of municipal waste and packaging waste by 2025, 2030 and 2035, target to landfill a maximum of 10% of municipal waste by 2035) and specific measures for their achievement. The WMP CR is also designed in accordance with the waste management hierarchy according to the Waste Framework Directive. Regional WMPs will also be updated to be in line with updated WMP CR all the targets arising from the EU waste legislation.

The main principles of the Waste Management Plan include:

- preventing the generation of waste
- maximising the recovery of waste as a substitute of primary resources and transition to the circular economy

- minimizing adverse impacts of the generation of waste on human health and environment
- reducing the quantity and dangerous properties of generated waste
- maximising the recovery of waste as a substitute of primary resources
- prevention in the form of reuse of product and improved generation efficiency

The update of the Secondary Raw Materials Policy of the Czech Republic for the period 2019–2022 contains important objectives for material efficiency such as:

- increasing the self-sufficiency of the Czech Republic in raw material resources by replacing primary resources with secondary raw materials
- supporting innovations and development of the circular economy within business
- supporting the use of secondary raw materials as a tool for reducing the material and energy intensity of industrial production
- supporting intensively education and training in the field of circular economy
- updating statistical surveys in the area of secondary raw materials to monitor and evaluate the circular economy

2.11.2 European targets

A positive trend is identified in the area of target for recycling of municipal waste according to Article 11 of the Waste Framework Directive but achieving the goals will be a challenge for the Czech Republic. In 2020 the Czech Republic adopted new weaste legislation with measures and tools that should lead to reaching the targets for recycling of municipal and packaging waste by years 2025, 2030 and 2035.

The target for construction and demolition waste according to Article 11 (70%) has been already reached. In year 2019 71.5% was reported.

2.11.3 Total generation of waste

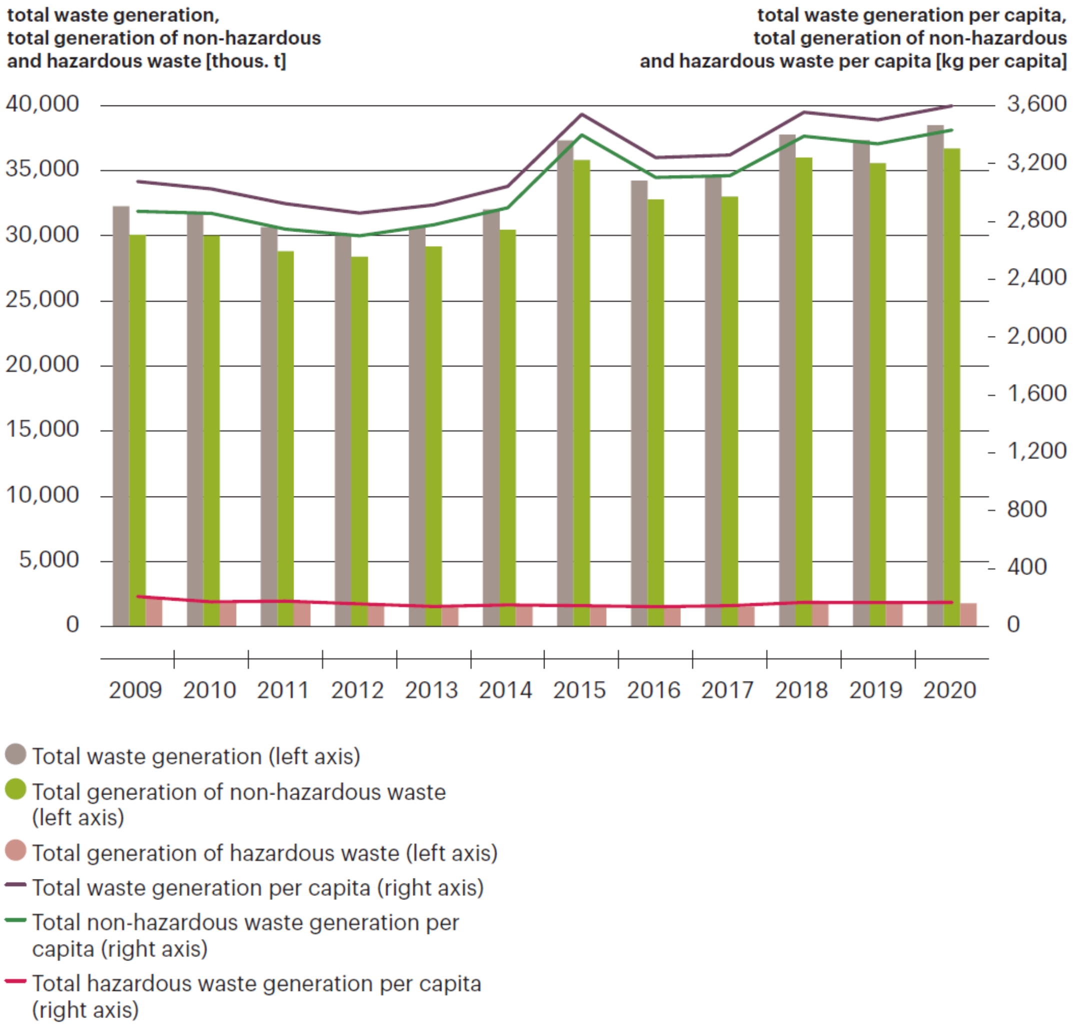
A key current trend in waste management is the move towards a **circular economy**, whereby material flows are closed in long-term cycles and the emphasis is on waste prevention, product reuse, recycling and conversion to energy instead of mineral extraction and landfilling.

Total waste generation (the sum of total generation of other and hazardous waste) increased by 19.3% between 2009 and 2020 and by 3.1% between 2019 and 2020 to 38,503.7 thous. t (**Chyba! Nenalezen zdroj odkazů.**Figure 2.16). It has a significant upward trend in the medium and short term. Reducing waste generation is possible by preventing its origin, which is in line with the principles of circular economy. Another important indicator is total waste generation per capita, which in 2020 was 3,598.4 kg per capita.

Total generation of **non-hazardous waste** accounts for a significant share of total waste generation (95.4% in 2020). This is mainly influenced by the generation of construction and demolition waste. Between 2009 and 2020, the total generation of non-hazardous waste increased by 22.0% and by 3.1% between 2019 and 2020 to 36,721.8 thous. t. In the medium and short term it has a significantly increasing trend, as does the total generation of waste. The total per capita generation of non-hazardous waste in 2020 was 3,431.9 kg per capita.

Hazardous waste accounted for 4.6% of total waste generation in 2020. The value of this share has fallen from 6.7% since 2009. In the 2009–2020 period, the total generation of hazardous waste decreased by 17.6% to a total of 1,781.8 thous. t despite a year-on-year increase of 1.3% in 2019–2020. Total hazardous waste generation per capita in 2020 was 166.5 kg per capita. This waste can be prevented by reducing the hazardous substances in products.

Figure 2.16: Total generation of waste, non-hazardous and hazardous waste in the Czech Republic [thous. t], total generation of waste, non-hazardous and hazardous waste per capita in the Czech Republic [kg per capita], 2009–2020



The data was determined using the methodology Mathematical expression of the "Waste management indicator system" calculation valid for the given year. Czech Statistical Office is the source of data on the population of the Czech Republic (mid-year population).

Data source: CENIA, Czech Statistical Office

Table 2.22: Total generation of waste in the Czech Republic [thousands of tons], 2009–2020

Year	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Total production of waste (thousands of tonnes)	32 267	31 811	30 672	30 023	30621	32 028	37 338	34 242	34512	37784	37362	38503

Source: Ministry of the Environment - Waste Management Plan Indicators

2.11.4 Generation and treatment of municipal waste

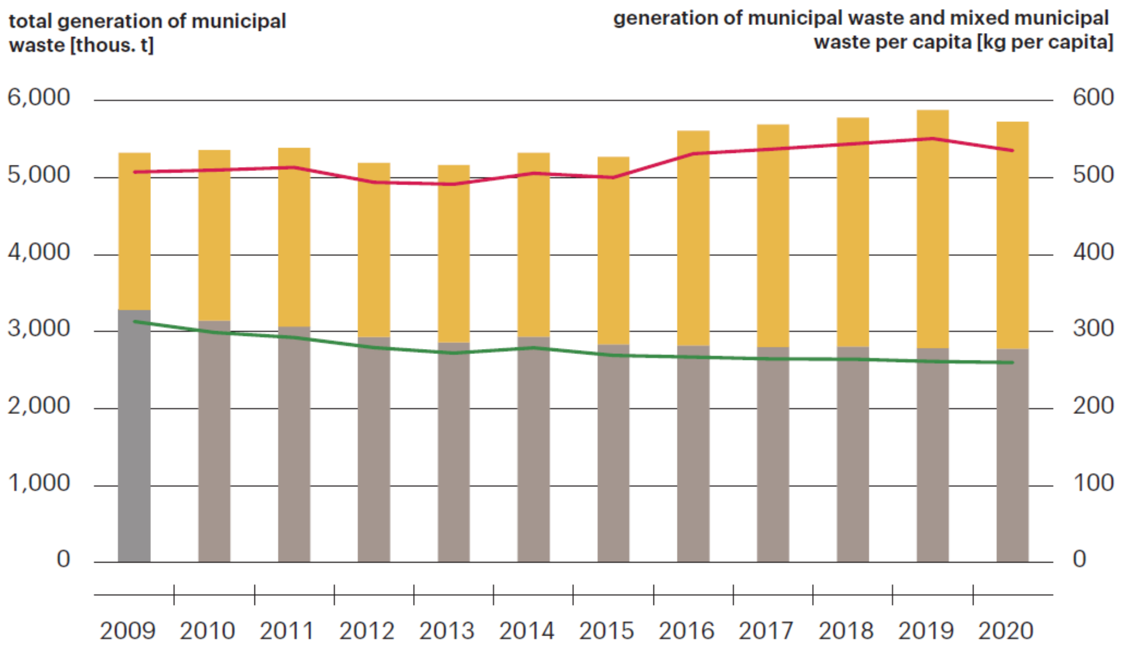
Total municipal waste generation decreased by 2.5% year-on-year to 5,729.9 thous. t in 2019–2020 (Figure 2.17). Since 2009, however, there has been a 7.6% increase. It is also increasing in the medium term. The total per capita generation of municipal waste in 2020 was 535.5 kg per capita. On the positive side, there is a slight reduction in the **generation of mixed municipal waste** in the medium term. Between 2009 and 2020, the generation of mixed municipal waste decreased by 15.3% and by 0.3% between 2019 and 2020 to a total of 2,780.3 thous. t. The total generation of mixed municipal waste per capita in 2020 was 259.8 kg per capita.

Table 2.23: Total production of municipal waste in the Czech Republic, 2009 - 2020

Year	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Total production of municipal waste (1000 t/year)	5 125	5 224	5 388	5 188	5 168	5 324	5 274	5612	5690	5782	5879	5729

Source: Ministry of the Environment - Waste Management Plan Indicators

Figure 2.17: Total generation of municipal waste in the Czech Republic [thous. t], per capita generation of municipal and mixed municipal waste in the Czech Republic [kg per capita], 2009–2020



● Municipal waste, except for mixed municipal waste (left axis)
● Mixed municipal waste (left axis)
— Municipal waste per capita (right axis)
— Mixed municipal waste per capita (right axis)

The data was determined using the methodology Mathematical expression of the "Waste management indicator system" calculation valid for the given year. Czech Statistical Office is the source of data on the population of the Czech Republic (mid-year population).

Data source: CENIA, Czech Statistical Office

Municipal waste is a specific group of waste, and this is reflected in the way it is **treated**. Unlike other waste groups, disposal **by landfilling** dominates in this case. However, the share of municipal waste landfilled fell from 64.0% to 47.8% in the 2009–2020 period. However, in a year-on-year comparison between 2019 and 2020, the share of municipal waste disposed of by landfilling of the total municipal waste generation of 5,729.9 thous. t in 2020 increased from 45.9% to 47.8%. A downward trend can be observed in the medium term, but there has been an increase in the short term (since 2016). In 2020, the amount of municipal waste disposed of by landfilling was 2,737.3 thous. t.

Diversion from landfilling is increasing the share of municipal waste used for material recovery, which increased from 22.7% in 2009 to 38.6% in 2020, despite a year-on-year decrease from 41.0% to 38.6% 2019–2020. It has a significantly increasing trend in the medium term. The amount of material recovery of municipal waste was 2,213.8 thous. t in 2020.

At the same time, the importance of energy recovery from municipal waste also increased, from 6.0% in 2009 to 12.6% in 2020. The share of municipal waste used for energy recovery increased from 11.7% to 12.6% year-on-year 2019–2020. It has a slightly increasing trend in the medium term. The amount of energy recovery of municipal waste was 721.2 thous. t in 2020.

The situation is diametrically different for **incineration**, through which an almost negligible amount of municipal waste is treated (4.4 thous. t in 2020). In this case, the percentage share is almost zero (0.08% in 2020).

Nevertheless, the municipal waste treatment situation in the Czech Republic is not satisfactory (municipal waste landfilling is above the EU28 average and recycling below the average). The aim is to reduce the share of landfilling in total municipal waste generation more drastically and at the same time to increase its material and energy recovery, in accordance with the current waste treatment method hierarchy and circular economy principles associated with the need to meet European circular economy targets. If current trends continue, achieving the 2025, 2030 and 2035 municipal waste recycling and 2035 municipal waste landfilling targets will be challenging.

2.12 Agriculture

Agriculture has typical central European character with predominance of food production and high share of arable land (70.8%). Zonal character of agriculture is driven by altitude rather than latitude. Agricultural production is sufficient to cover domestic demand in terms of basic products. Crop production prevails over animal production. Yield converted to area is lower than in neighbouring countries. Contribution of agriculture to GDP is about average in the EU.

Cropland in the Czech Republic, same as in other EU Member States, suffers from real estate development; despite that the Czech Republic remains one of the countries with the large shares of crop land / total area in the EU. Then main crop is grain, especially wheat. Wheat fields have been growing in recent years to the detriment of forage crops. The largest area is taken up by wheat and barley fields, corn (mass and seeds), rape, sugar beet and oat fields. Yields from these main crops have been growing, but regardless of that the Czech Republic is among the medium successful wheat producers.

In the past there has been a marked drop in the number in livestock, despite that fact that livestock numbers grew in certain neighbouring countries. This is apparent in international comparison, where livestock numbers are below average even within the framework of the EU. Animal production corresponds to livestock numbers, and within the EU the meat production is also below average.

Table 2.24: Average animal breeding for 2016 - 2020 (thousands of animals)

Thousand of animals	2016	2017	2018	2019	2020
Cattle total	1 415.7	1 421.2	1 415.8	1 418.1	1 404.1
Particularly cows	583.7	585.9	587.3	590.5	585.9
Particularly suckler cows (non-dairy cows)	211.2	216.1	221.9	226.3	226.0
Pigs	1 609.9	1 490.8	1 557.2	1 544.1	1 499.3
Poultry	21 313.96	21 494.3	23 572.8	22 979.4	24 247.4
Particularly layers	8 923.7	9 282.98	9 194.4	9 440.6	9 204.5
Sheeps	218.5	217.1	219.9	213.1	203.6
Goats	26.6	28.2	30.3	29.2	28.9

Sources: Institute of Agricultural Economics and Information, MoA

From the total territory of the state (approximately 7.9 million ha) the agricultural / farming land took up 53.4% in 2020 (in 2003 it was 54.1%), which represents approximately 0.4 ha per inhabitant. Consumption of mineral fertilizer in recent years is shown in Table 2.26.

Development of organic farming shows a positive trend. The number of organic farms has been steadily growing in the recent years. Numbers of distributors and producers of bio food are also growing.

Table 2.25: Development of organic farms and area of cropland in the organic farming system in the Czech Republic

Year	**Total number of enterprises (organics farms)**	**Area in ha**	**Percentage share on agricultural land fund**
1990	3	480	-
1991	132	17 507	0.41
1992	135	15 371	0.36
1993	141	15 667	0.37
1994	187	15 818	0.37
1995	181	14 982	0.35
1996	182	17 022	0.40
1997	211	20 239	0.47
1998	348	71 621	1.67
1999	473	110 756	2.58
2000	563	165 699	3.86
2001	654	217 869	5.09
2002	721	235 136	5.50
2003	810	254 995	5.97
2004	836	263 299	6.16
2005	829	254 982	5.98
2006	963	281 535	6.61
2007	1318	312 890	7.35
2008	1 946	341 632	8.04
2009	2 689	398 407	9.38
2010	3 517	448 202	10.55
2011	3 920	482 927	11.40
2012	3 923	488 483	11.56
2013	3 926	493 896	11.70
2014	3 885	493 971	11.72
2015	4 115	494 661	11.74
2016	4 243	506 070	12.03
2017	4 399	520 032	12.37
2018	4 606	538 223	12.80
2019	4 690	540 993	15.22
2020	4 665	543 252	15.28

Source: MoA

The number of registered enterprises and area of cropland involved in integrated production has also risen.

In 2007, the state introduced mandatory mixing of bio-compounds into fuels; this measure continues to apply. Bio compounds involved include rapeseed methyl-ester (MERO – FAME) and bio-ethanol, produced mostly from sugar beet. This measure resulted in growing area dedicated to growing rapeseed. Agriculture contributed in 2015 to production of all greenhouse gases in the Czech Republic by 7% (incl. LULUCF sector).

In 2020, the CH_4, N_2O and CO_2 emissions reached the total of 7 841.83 kt CO_2 eq. Agriculture is the largest source of N_2O emissions (76% of the total N_2O emissions) and second largest source for CH_4 (30% of total emissions of CH_4)[9].

After 1990, when agriculture sector transformed, there has been a considerable decrease in the use of mineral fertiliser and calcic substances due to savings in funding. In 1994 the application of mineral fertiliser and calcic substances rose again and since then it has been fluctuating slightly. At present time, the fertiliser application in the Czech Republic in comparison with the EU average is, more often than not, lower.

Table 2.26: Development of mineral fertiliser use 2005–2020 (kg/ha)

Fertiliser type	**Economic year**						
	2005/ 2006	**2006/ 2007**	**2007/ 2008**	**2008/ 2009**	**2009/ 2010**	**2010/ 2011**	**2011/ 2012**
Total	98.9	104.6	110.5	98.0	99.8	108.1	113.2
In that:							
Nitric	74.1	77.6	82.2	78.1	80.2	84.9	88.3
Phosphate	14.9	16.3	16.9	12.4	12.4	14.2	15.3
Potassium	9.9	10.7	11.4	7.5	7.2	9.0	9.6

Fertiliser type	**Economic year (continued)**						
	2013/ 2014	**2014/ 2015**	**2015/ 2016**	**2016/ 2017**	**2017/ 2018**	**2018/ 2019**	**2019/ 2020**
Total	127.9	130.7	141.0	139.5	137.5	134.6	134.1
In that:							
Nitric	97.2	98.7	107.3	104.9	103.2	101.1	99.6
Phosphate	18.4	19.0	19.9	20.5	20.1	19.4	20.7
Potassium	12.3	13.0	13.9	14.1	14.2	14.0	13.8

Note: In the Czech Republic, the figures for phosphate and nitric fertiliser give values for the amount of relevant oxides, while in number of countries the value means directly the amounts of phosphorus or nitrate.

Source: CzSO

[9] National Inventory Report (NIR), CHMI, 2022

2.14 Forestry

The Czech Republic is one of countries with high forest coverage. The area of forests has been growing since the second half of the 20th century, mostly due to long-term trend of afforestation of infertile cropland (in recent years the annual gain is approximately 2 000 ha). Total area of forestland in 2020 reached 2 677 thousand ha, which is approximately one third of the Czech territory (34.0% of the total territory). During afforestation, there has been recent effort to increase the share of broadleaved species at the expense of conifers. In 2020, 70.4% of forests were coniferous forests (76.5% in 2000) and 28.2% broadleaved (22.3% in 2000). Total wood supply in the Czech Republic has been growing and in 2020 it reached 701.1 million m^3 (Table 2.28).

Table 2.27: Trends in the area of forest land in 1920 – 2020 (thousand ha)

	1920	1930	1945	1950	1960	1970	1980	1990	2000	2005	2010	2015	2018	2019	2020
Area	2 369	2 354	2 420	2 479	2 574	2 606	2 623	2 629	2 637	2 647	2 657	2 668	2 673	2 676	2 677

Source: MoA, COSMC

Table 2.28: Trends in the total standing stock of wood in forests in 1930 – 2020 (million m^3)

	1930	1950	1960	1970	1980	1990	1998	1999	2000	2005	2010	2015	2018	2019	2020
Standing stock	307	322	348	445	536	564	615	625	630	663	681	693	703	705	701

Source: MoA

Table 2.29: Trends in some basic characteristics of forest management in 1990 – 2020 (million m^3/year)

	1990	**1995**	**2000**	**2005**	**2010**	**2015**	**2018**	**2019**	**2020**
Total harvesting	13.3	12.4	14.4	15.5	16.7	16.2	25.7	32.6	35.8
Salvage logging	9.8	7.9	3.3	4.5	6.1	8.2	23.0	30.9	33.9
Salvage logging in % from total harvesting	74%	64%	23%	29%	36%	51%	89%	95%	95%
Total increment	17.0	18.0	19.8	20.5	21.2	21.8	22.3	22.4	22.4
Ratio of increment and harvesting	78%	69%	73%	76%	79%	74%	115%	146%	160%

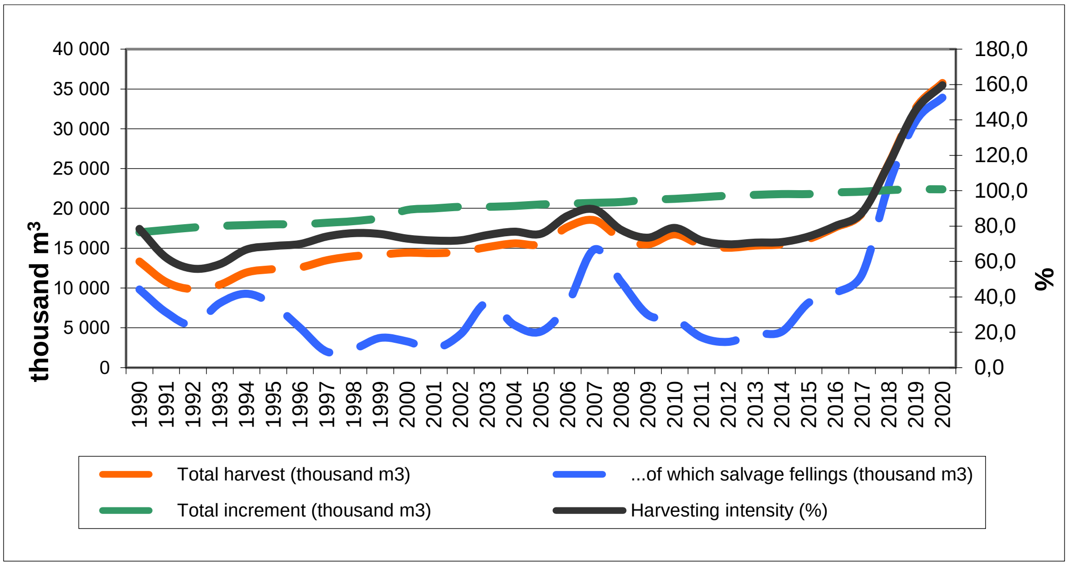
Source: MoA, FMI, CzSO

The basic information on the forest economy is given in Table 2.29 and Figure 2.19. Historically, salvage logging following the Kyrill windstorm in January 2007 caused the record-breaking logging yield in 2007 which was lately surpassed by salvage loggings resulting from period of droughts followed by bark-beetle outbreak.

With regard to the ownership, 53.76% of the forests is owned by the state, 17.19% by cities and municipalities, 19.12% by private persons, 3.41% by legal entities, 5.32% forest owned by church and religious entities and 1.20% by other owners (2020 data). Lesy CR, s.p. (Forests of the Czech Republic, a state enterprise), respectively Vojenske lesy a statky CR, s.p. (Military Forests and Farms Forests, a state enterprise) and National Park Administrations manage forests owned by the state. With regard to the function of forests, there are economic forests (74.2%), protective forests (2.0%) and special-use forests (23.8%). Economically driven forests growths are administered by the Ministry of Agriculture. Forests in national parks and in their protective zones are administered by the Ministry of the Environment. Forests in national parks are the so-called special-use forests. The share of forestry sector in the creation of gross value added fluctuates between 0.6 and 0.9% in recent years (in normal prices).

Forests have been severely damaged in previous decades by industrial exhalations. Despite dramatic decrease in pollutant emissions into air (especially SO_2) the health of the forests is improving only very slowly. The cause of the current damage to forests lies especially in the long-term cumulative degradation of forest soil due to pollutants burden followed by consequencies of long term droughts and subsequent bark-beetle attacks which led to unprecedented amounts of salvage loggings in the latest years.

Figure 2.19: Comparison of total increment with harvesting [thousand m^3]



Source: Forest Management Insitute

Broadleaved species have been gaining at the expense of conifers in terms of forest composition, which is becoming more mixed, spruce and pine is on the retreat, being replaced by beech, oak, ash and maple tree. This is a result of a long-term effort to achieve a more balanced and natural composition of the forests in the Czech Republic and partially of a specific financial support of the state focusing on ensuring the necessary ratio of ameliorative and reinforcing woody species during restoration of the forests.

Air pollution has a great effect on the forest health and pollution weakens growth. Forest health condition is characterized mainly by the degree of defoliation. Significant reduction of air pollutants burden in recent years has undoubtedly influenced the condition of forests, where the impact is apparent with some delay. Forests however continue to demonstrate large degree of defoliation, which is among the highest in comparison with other European countries and in the long-term, despite certain fluctuations, it continues to slightly grow. High defoliation is caused by continuing effects of air pollutants, even if at lower rates, but also by the fact that stability of forest ecosystems has been disrupted in the long term due to ruinous air pollutants levels in the past. Defoliation is also caused by other negative factors of biotic and abiotic nature, some of which have been growing in significance over the recent years (climatic extremes, insect living under bark).

The **Land Use, Land-Use Change and Forestry** (**LULUCF**) sector closely relates to agriculture and forestry. The most important land category in LULUCF sector in the Czech

Republic with regard to greenhouse gases emission balance are forested areas. Forestry in the Czech Republic is regulated by the Forest Act (Act No. 289/1995 Coll., on Forests, as amended), which forms the fundamental legislative instrument. While this Act does not directly determine the specific targets for forest carbon stocks, its provisions regulate carbon stocks and reduction of greenhouse gas emissions in many respects indirectly. The purpose of this Act is to determine conditions for the preservation, tending and regeneration of forests as national riches to enable the fulfillment of all their functions and to support sustainable forestry.

In general, the area of clear felling must not exceed one hectare and a cleared area of forest land must be afforested within two years. The most important instrument are the Forest Management Plans (or Guidelines for areas under 50 ha) which include binding provisions for maximum fellings and minimal share of soil-improving and reinforcing species and other provisions and recommendations.

A strong emphasis has been placed on issues related to carbon stocks and emissions from the forestry sector during negotiation and elaboration of the National Forestry Programme II. This programme has been approved by the Government Resolution No. 1221/2008 and should lead to a draft forestry bill, which will contain specific measures preventing climate change and promoting adaptation to climate change in the forestry sector. The National Forestry Programme contains "Key Action 6" – aiming to "Reduce impacts of anticipated global climate change and extreme meteorological events", which is itself based on 12 specific measures. These measures are generally focusing on creating more resilient forest ecosystems by supporting diversified growth with the highest possible use of natural processes, diverse wood plant composition, natural capacity for restoration and variability of afforestation methods.

Together with Principles of State Forest Policy (Decree No. 854 of 21 November 2012) which include also enhancing biodiversity in forest ecosystems, their integrity and ecological stability as one of the main principles, the above mentioned documents form a framework which ensures that the implementation of activities under Article 3.3 and 3.4 contribute to conservation of biodiversity and sustainable use of natural resources.

Emissions and removals amounted to 12 771.80 kt CO_2 eq. in 2020, which corresponds to 10% of total national emissions.

LULUCF sector is currently no longer a sink of CO_2. Starting with 2015 the removals decreased and resulted in emissions since 2018. The situation is caused by the extreme drought-induced accelerating bark-beetle outbreak calamity experienced in the Czech forestry in the recent years (since 2015). The emissions are mainly driven by salvage logging operations (see Table 2.29 and Figure 2.19). While the emissions from the LULUCF sector have probably peaked the Czech Republic may not reach sinks in this sector by 2030.

Table 2.30: Area according to category IPCC [thousand ha]

Territorial category	1990	2015	2016	2017	2018	2019	2020
Forest Land	2 629.5	2 668.4	2 669.9	2 671.7	2 673.4	2 675.7	2 677.3
Grassland	832.5	1000.6	1003.4	1006.6	1 011.1	1 017.6	1 022.7
Cropland	3 455.0	3 211.3	3 205.0	3 198.7	3 192.6	3 184.6	3 177.3
Wetlands	157.5	165.5	165.9	166.3	166.6	166.8	167.4
Settlements	811.9	841.2	842.9	843.8	843.4	842.4	842.2
Other	NO	NO	NO	NO	NO	NO	NO

Source: CHMI

Table 2.21: Emissions (+) and sinks (-) from LULUCF in 2020 [Gg CO_2 eq.]

Emissions (+) and sink (-) [Gg CO_2 eq.]	CO_2	CH_4	N_2O	Total
LULUCF	**12 719.42**	**29.86**	**22.82**	**12 771.80**
Forest Land	14 732.07	29.86	19.69	14 781.62
Cropland	30.20	NO	2.31	32.51
Grassland	-493.24	NO	NO,NA	-493.24
Wetlands	34.36	NO,NA	NO,NA	34.36
Settlements	146.22	NO,NA	NO,NA	146.22
Harvested wood products	-1 730.19	-	-	-1 730.19
Other	NO	NO	NO	7.55

Source: CHMI

LULUCF contribution to the fulfilment of reduction commitment of the Czech Republic will be accounted for, in accordance with rules set forth by Kyoto Protocol (KP), at the end of the second Kyoto commitment period same as for the first commitment period. The Czech Republic has elected accounting of forest management activities pursuant to KP Art. 3.4 for the first Kyoto commitment period and continues to accounting this category in the second commitment period. This category remains most significant from the perspective of LULUCF sector emissions stocks. Taking into account the the FMRL -4686 kt CO_2eq., the proposed technical correction of -225 kt CO_2eq. and the emisions in the later part of the period the total accounting quantity for the seond commitment period should be 38 365.28 kt CO_2eq.

Table 2.32: Additional information on emissions (+) and sink (-) from KP activities 2013 - 2020 [Gg CO_2 eq.]

Year	Activities as defined in KP Art. 3.3		Activities as defined in KP Art. 3.4
	Afforestation and reforestation	**Deforestation**	**Forest management**
2013	-517.08	257.78	-6 242.65
2014	-551.26	256.17	-6 073.49
2015	-585.98	215.23	-5 846.04
2016	-608.93	244.11	-4 970.40
2017	-641.38	259.48	-3 299.29
2018	-664.03	198.20	2 402.14
2019	-699.23	201.88	9 280.95
2020	-712.00	247.85	13 826.02

Source: CHMI

Besides the serious impact of natural disturbances, the balance in the following years is also expected to be temporarily negatively affected by the planned increase in the share of broadleaved species. This measure is however a significant adaptation measure, which aims to ensure long-term stability of forest stands and therefore also carbon accumulation over long-term horizon. In the future, we also expect a more extensive use of biomass for energy purposes and larger volumes of carbon accumulated in harvested wood products.

3 GREENHOUSE GAS INVENTORY INFORMATION

3.1 Summary tables

This chapter describes greenhouse gas emissions (GHGs) trends over time, covering period between 1990 and 2020. The Czech Republic is obliged to report on GHGs to the European Commission on the basis of the Regulation (EU) No. 525/2013 and to the Secretariat of the United Nations Framework Convention on Climate Change.

In 2020, the most important GHG in the Czech Republic was CO_2 contributing 83.3% to total national GHG emissions and removals expressed in CO_2 eq., followed by CH_4 9.2% and N_2O 4.3%. PFCs, HFCs, SF_6 and NF_3 contributed for 3.3% to the overall GHG emissions in the country.

Over the period 1990 - 2020 CO_2 emissions and removals decreased by 32.6%, CH_4 emissions decreased by 50.7% during the same period mainly due to lower emissions from 1 Energy and 3 Agriculture; N_2O emissions decreased by 42.7% over the same period due to emission reduction in 3 Agriculture. Emissions of HFCs and PFCs increased by orders of magnitude, whereas SF_6 emissions kept steady trend over the whole period.

In 2020, 84 581.01 kt CO_2 eq., that are 67.36% of national total emissions (including 4 Land Use, Land-Use Change and Forestry) arose from 1 Energy; 97.27% of these emissions arise from fuel combustion activities. The most important sub-category of 1 Energy with 49.19% of total sectoral emissions in 2020 is 1.A.1 Energy Industries, 1.A.2 Manufacturing Industries and Construction responses for 12.11% and 1.A.3 Transport for 21.03% of total sectoral emissions. From 1990 to 2020 emissions from 1 Energy decreased by 47.52%.

2 Industrial Processes is the second largest category with 12.13% of total GHG emissions (including 4 Land Use, Land-Use Change and Forestry) in 2020 (15 229.96 kt CO_2 eq.); the largest sub-category is 2.C Metal Production with 39.04% of sectoral share. From 1990 to 2020 emissions from 2 Industrial Processes decreased by 11.71%.

3 Agriculture is the third largest category in the Czech Republic with 6.25% share of total GHG emissions (including 4 Land Use, Land-Use Change and Forestry) in 2020 (7 841.83 kt CO_2 eq.); 46.21% of these emissions arose from 3.D Agricultural Soils. From 1990 to 2020 emissions from 3 Agriculture decreased by 49.45%.

4 Land Use, Land-Use Change and Forestry is contributing with 10.17% to the total GHG emissions (12 771.80 kt CO_2 eq.). Subcategory 4.A. Forest Land contributes to these emissions by more than 100%; the total emissions are lowered thanks to the removal in 4.G Harvested Wood Products and 4.C Grassland.

5 Waste contribution to the total GHG emissions is (including 4 Land Use, Land-Use Change and Forestry) 4.09% in 2020; 64.13% share of these emissions arose from 5.A Solid waste disposal. Emissions from 5 Waste increased from 1990 to 2020 by 70.38% to 5 135.78 kt CO_2 eq.

Table 3.1 presents a summary of GHG emissions excl. bunkers emissions for the period from 1990 to 2020. For CO_2, CH_4 and N_2O the base year is 1990; for F-gases the base year is 1995.

Table 3.1: Trends in greenhouse gas emissions in the 1990–2020 period [kt CO_2 eq.]

	CO_2[1]	CH_4[3]	N_2O[3]	HFCs	PFCs	NF_3	SF_6	Total emissions[4] excl. LULUCF	incl. LULUCF
1990	164210.75	23422.97	9287.95	NO			84.24	198847.99	189911.77
1991	148879.30	21849.69	7949.06				84.08	180409.59	170083.22
1992	145710.61	20436.21	7127.32				85.41	174908.24	164524.98
1993	140129.09	19537.43	6396.34				86.56	167657.33	156589.51
1994	132673.28	18397.72	6288.73				87.66	158896.75	149126.53
1995	131627.14	17970.32	6583.19	95.55	0.01	NO	88.68	157775.95	147738.40
1996	135004.35	17807.56	6341.56	236.86	0.68	NO	98.31	160855.20	151023.61
1997	130834.17	17385.43	6309.57	424.68	1.73	NO	96.10	156381.29	147533.37
1998	125427.26	16666.72	6191.94	577.00	1.66	NO	94.98	150258.37	141697.30
1999	116569.94	15917.35	5981.48	691.91	1.10	NO	95.94	140469.17	131749.21
2000	127155.96	15094.56	6404.25	867.51	4.69	NO	108.40	150788.09	141399.99
2001	127030.01	14847.75	6673.07	1080.90	9.75	NO	98.82	150847.76	141544.32
2002	123946.89	14596.39	6273.72	1187.46	16.39	NO	121.28	147210.35	138171.36
2003	127478.65	14573.73	5786.40	1306.78	8.55	NO	144.69	150342.54	141898.62
2004	128247.53	14093.13	6449.87	1431.12	12.81	NO	120.61	151364.66	143130.24
2005	125688.56	14587.43	6294.98	1450.02	14.89	NO	111.84	149207.27	140867.57
2006	126566.10	14851.88	6172.68	1705.38	31.09	NO	105.12	150525.72	143407.06
2007	128369.91	14386.59	6238.31	2086.49	29.00	NO	93.79	152231.65	145716.58
2008	122912.26	14454.41	6304.95	2367.84	39.76	NO	88.67	147184.44	139353.05
2009	115013.22	13804.67	5463.68	2382.87	45.44	NO	89.05	137720.53	130005.64
2010	117482.15	14034.73	5347.92	2608.38	48.06	0.15	82.76	140533.11	133493.58
2011	115185.84	14034.30	5989.66	2833.83	8.31	0.59	88.64	139080.52	131723.06
2012	111280.67	14027.17	5851.44	2944.46	6.31	0.89	92.44	135097.60	127620.82
2013	106711.39	13424.84	5627.63	3084.11	4.22	1.41	83.04	129735.13	122902.85
2014	104228.85	13426.21	5739.33	3276.27	3.17	2.37	79.90	127553.95	120804.39
2015	104995.66	13428.87	6136.66	3544.88	2.15	2.15	78.27	128955.70	122277.33
2016	106655.72	12699.34	6284.87	3783.94	1.82	2.15	78.63	130254.50	124461.24
2017	107747.75	12506.90	6214.87	4017.36	2.03	3.33	74.03	131272.25	127156.68
2018	106337.97	12402.74	5862.23	4076.88	2.13	3.11	70.56	129427.31	130834.83
2019	101012.96	12119.40	5606.61	4112.18	1.62	2.52	68.00	123551.59	131786.88
2020	91853.88	11548.52	5328.32	4019.39	1.02	2.15	65.16	113338.55	126110.35
%[2)]	**-44.06**	**-50.72**	**-42.63**	**4106.42**	**11398.69**	**NA**	**-22.65**	**-43.00**	**-33.60**

Note: Global warming potentials (GWPs) used (100 years time horizon): CH_4 = 25; N_2O = 298; SF_6 = 22 800; NF_3 = 17 200; HFCs and PFCs consist of different substances, therefore GWPs have to be calculated individually depending on substances

[1]GHG emissions excluding emissions/removals from LULUCF

[2] relative to base year

[3]incl. LULUCF

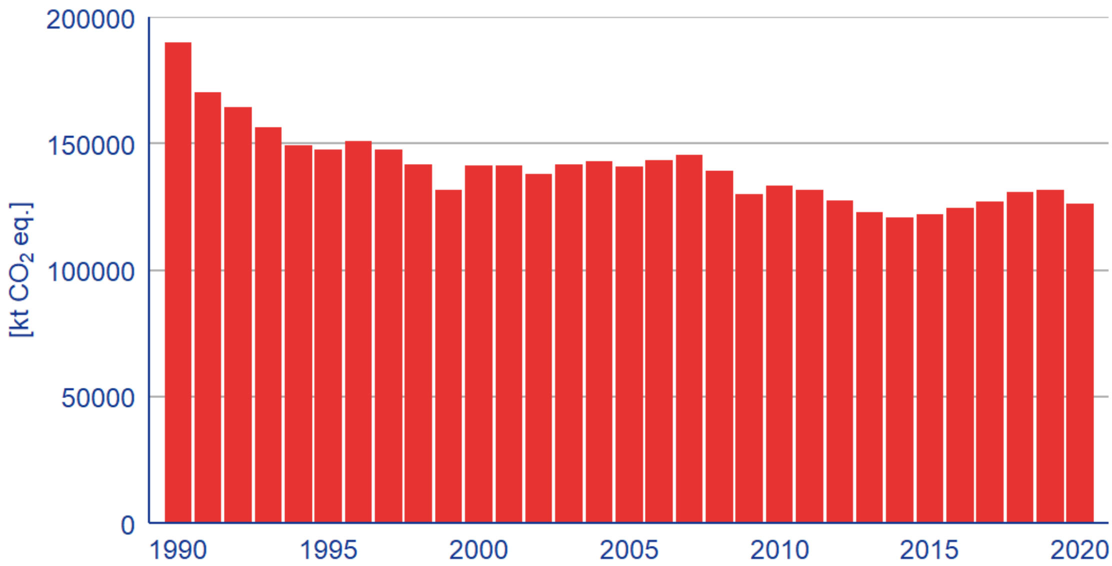
[4] incl.indirect emissions

Source: CHMI

GHG emissions and removals have significantly decreased in the period 1990 – 1995, mainly driven by the economy transition and pursuing major dropdown in heavy industry activities in the country. The fast decrease has stopped around 158 000 kt CO_2 eq. and continues fluctuating ever since (see Figure 3.1). From 2010 to 2020 the total GHG emissions (incl. indirect emissions and incl. LULUCF) decreased by approximately 6% or 7 383.24 kt CO_2 eq. resulting in total emissions of 126 110.35 kt CO_2 eq. The total emissions excluding LULUCF decreased by 19% or -27 194.57 kt CO_2 eq. The difference in the trend between including/excluding LULUCF is caused by huge increase in emissions from LULUCF in recent years.

The total GHG emissions and removals in 2020 were -33.60% below the base year level incl. LULUCF and indirect emissions and -43.00%, when excl. LULUCF.

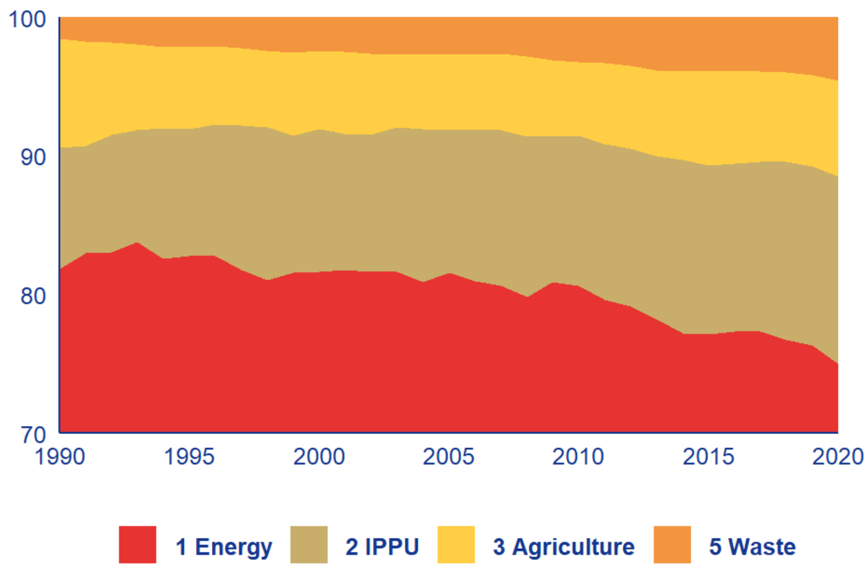
Figure 3.1: Trends in greenhouse gas emissions in the 1990–2020 period (kt CO_2 eq.)



Source: CHMI

In 1989 the Czechoslovak economy was one of the centrally planned economies with high level of monopolization. All economic processes were controlled through central planning. For all practical purposes, there was no real market and this situation resulted in an ever deepening economic and technological lag which resulted in high energy and material inefficiency. Since 1989 to the present the economy transformed successfully to a developed market-driven economy. The transformation led to a decline in production and new investments in environmental protection, energy efficiency, fuel switch and increasing use of renewable energy. Greenhouse gases emission trend between 2007 and 2009 and supposedly up to present days passed through significant change driven mainly by economic recession.

Figure 3.2: Percentual share of GHGs (Y-axis begins at 70% - part of CO_2 share is hidden)



Source: CHMI

3.2 Descriptive summary

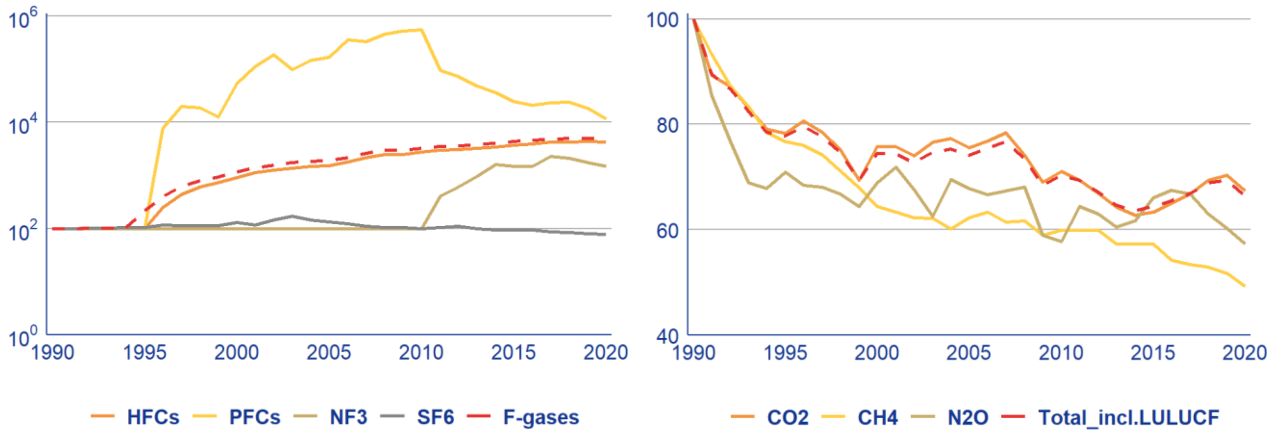
Inventories of greenhouse gases for the purposes of the UN Framework Convention on Climate Change monitor emissions and sinks of carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and F-gases emissions (HFCs, PFCs, SF_6 and NF_3). Besides these substances, the inventory also takes stock of precursors: volatile organic compounds (NMVOC), carbon monoxide (CO), nitrogen oxides (NO_X) and sulphur dioxide (SO_2). Emphasis is placed on accurate calculations of emissions of greenhouse gases with direct radiation absorption effect (CO_2, CH_4, N_2O, HFCs, PFCs, SF_6 and NF_3). The total impact of emissions of these gases is given as the aggregated emissions, expressed as the equivalent amount of carbon dioxide, taking into account the global warming potential values GWP for a time period of 100 years.

Greenhouse gas inventories are prepared in accordance with the standard IPCC method. A detailed description of the methodology, emission factors employed and activity data is contained in the National Inventory Report, which is updated annually[10].

3.2.1 Description and interpretation of emission trends by gas

The major greenhouse gas in the Czech Republic is CO_2, which represents 81% of total GHG emissions and removals in 2020, compared to 83% in the base year (excl. indirect emissions, excl. LULUCF). It is followed by CH_4 (10% in 2020, 12% in the base year), N_2O (5% in 2020, 5% in the base year) and F-gases (4% in 2020, 0.04% in 1990). The trend of individual GHG emissions relative to emissions in the respective base years is presented in Figure 3.3.

Figure 3.3 Trend in CO_2, CH_4 and N_2O emissions 1990–2020 in index form (base year = 100%) and Trend in HFCs, PFCs (1995 – 2020) and SF_6 (1990 – 2020) actual emissions in index form (base year = 100%)



Source: CHMI

Carbon dioxide

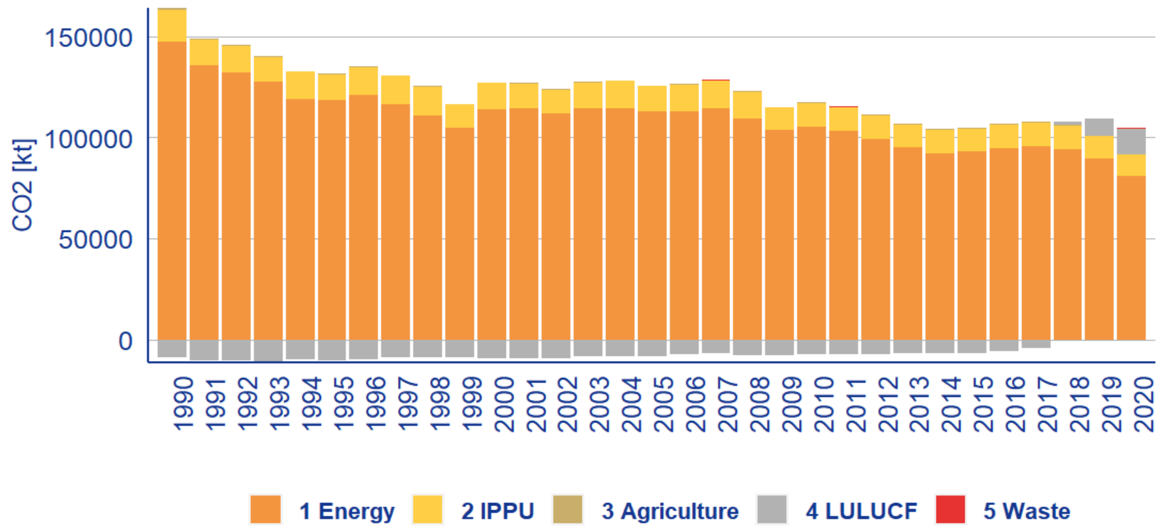
CO_2 emissions have been rapidly decreasing in early 90's, after 1994 the emissions have kept at average of 72% of the amount produced in 1990. Inter-annual decrease in CO_2 emissions (excl. LULUCF, exl. indirect emissions) from 2010 to 2020 by 22% results in the total decrease of 44.06% from 1990 to 2020. Quoting in absolute figures, CO_2 emissions and removals decreased from 164 210.75 to 91 853.88 kt CO_2 in the period from 1990 to 2020, mainly due

[10] National Inventory Report and data sets for each year are available at CHMI (http://portal.chmi.cz/files/portal/docs/uoco/oez/nis/nis_do_aj.html)

to lower emissions from the 1 Energy category (mainly 1.A.2 Manufacturing Industries & Construction, 1.A.4.a Commercial/Institutional and 1.A.4.b Residential).

The main source of CO_2 emissions is fossil fuel combustion; within the 1.A Fuel Combustion category, 1.A.1 Energy Industry and 1.A.4 Other sectors are the most important. CO_2 emissions increased remarkably between 1990 and 2020 from the 1.A.3 Transport category from 11 087.00 to 17 561.70 kt CO_2 eq.

Figure 3.4: Trends of CO_2 emissions and shares of individual sector in the Czech Republic 1990–2020 (kt CO_2)

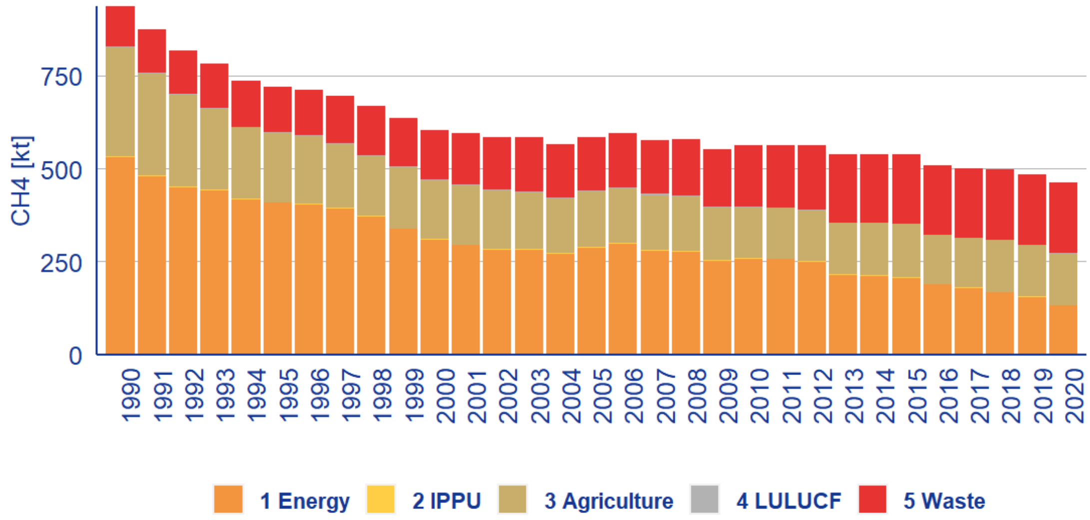


Source: CHMI

<u>Methane</u>

CH_4 emissions share decreased almost steadily during the period from 1990 to 2004, from 2004 methane fluctuated around 60% of its base year emissions. In 2020 CH_4 emissions were 51% below the base year level (incl. LULUCF), mainly due to lower contribution of 1.B Fugitive Emissions from Fuels and emissions from 3 Agriculture and despite increase from the 5 Waste category. The main sources of CH_4 emissions are 1.B Fugitive Emissions from Fuels (solid fuel), 3.A Enteric Fermentation and 5.A Solid Waste Disposal on Land.

Figure 3.5: Trends of CH_4 emissions and shares of individual sector in the Czech Republic in the 1990–2020 period (kt CH_4)



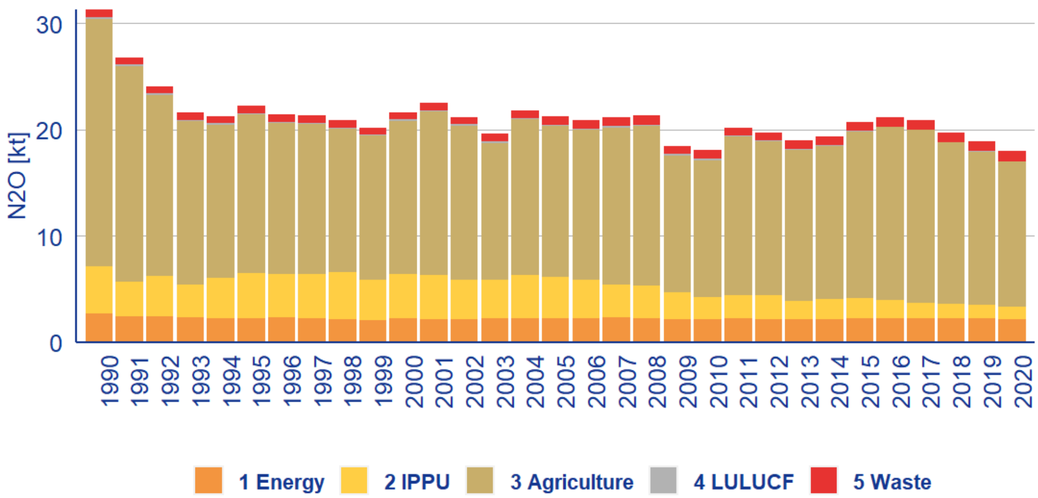
Source: CHMI

<u>Nitrous oxide</u>

N_2O emissions strongly decreased from 1990 to 1994 by 32% over this period and then shows slow decreasing trend with inter-annual fluctuation. N_2O emissions decreased between 1990 and 2020 from 9 287.95 to 5 328.32 kt CO_2 eq. (incl. LULUCF). In 2020 N_2O emissions were 43% below the base year level, mainly due to lower emissions from 3 Agriculture and 2.B Chemical Industry and despite increase from the 5 Waste.

The main source of N_2O emission is category 3.D Agricultural Soils (others less important sources are 1.A Fossil Fuel Combustion and 2 Industrial Processes – 2.G Other product manufacture and use).

Figure 3.6: Trends of N_2O emissions and shares of individual sector in the Czech Republic in the 1990–2020 period (kt N_2O)



Source: CHMI

HFCs

HFCs actual emissions increased remarkably between 1995 and 2020 from 95.55 to 4 019.39 kt CO_2 eq. The rapid increase of emissions was driven mainly by increased consumption of HFCs in subcategory 2.F.1 Refrigeration and Air Conditioning. In 2020, HFCs emissions were more than 41-times higher than in the base year 1995.

The main sources of HFCs emissions are 2.F Product Uses as ODS substitutes (specifically above mentioned subcategory 2.F.1 Refrigeration and Air Conditioning). HFCs and PFCs were not imported and used before 1995.

PFCs

PFCs emissions rapidly increased between 1995 and 2010. Since 2010, PFCs emissions are decreasing to current level 1.02 kt CO_2 eq. Rapid decrease of emissions is caused by reduced consumption of PFCs.

The main sources of PFCs emissions are 2.E Semiconductor Manufacture and 2.F.1 Refrigeration and Air Conditioning equipment.

SF_6

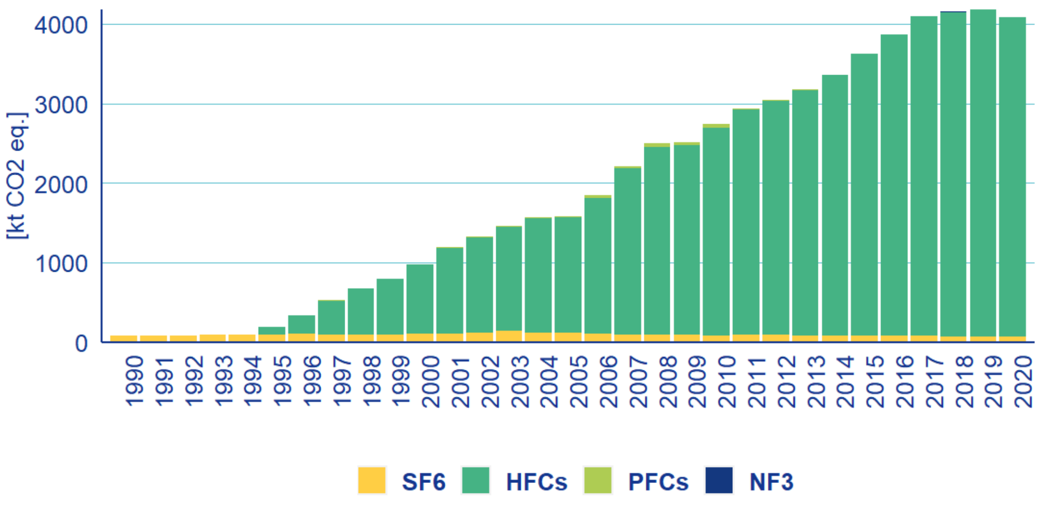
SF_6 emissions in 1995 accounted for 88.68 kt CO_2 eq. Between 1995 and 2020 they inter-annually fluctuated with maximum of 144.69 kt CO_2 eq. In 2020 SF6 reached amount of 65.16 kt CO_2 eq., the level was 26.52% lower than the base year (1995).

The main sources of SF_6 emissions is 2.G Other product manufacture and use.

NF_3

With the technological progress a new gas is used since 2010 in semiconductor manufacturing. NF_3 is a gas, used mainly for manufacturing of LCD displays, solar panels and etching semiconductors. Base year for this gas is 1995. In 2020 the emissions of NF_3 equalled to 2.15 kt CO_2 eq.

Figure 3.7: F-gases inventories in the 1990–2020 period (kt CO_2 eq.)



Source: CHMI

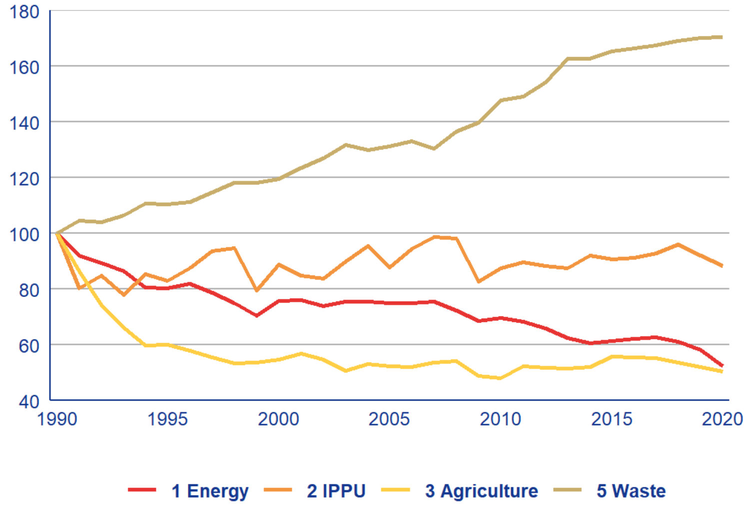
3.2.2 *Description and interpretation of emission trends by categories*

Table 3.2 presents a summary of GHG emissions by categories for the period from 1990 to 2020:

- Category 1 Energy
- Category 2 Industrial Processes and Product Use
- Category 3 Agriculture
- Category 4 LULUCF
- Category 5 Waste

The trend of GHG emissions by categories is presented in Figure 3.8 (indexed relative to the base year).

Figure 3.8: Emission trends in 1990–2020 by categories in index form (base year = 100)



Source: CHMI

The dominant category is the 1 Energy, which caused 67.1% of total GHG emissions in 2020 (84.9% in 1990) incl. LULUCF and indirect emissions, followed by the sectors 2 Industrial Processes and Product Use and 3 Agriculture, which caused 12.1% and 6.2% of total GHG emissions in 2020 (9.1% and 8.2% in 1990, resp.), 5 Waste sector covered 4.1% (1.6% in 1990) and 4 LULUCF category caused 12.1% (removals prevailed in 1990).

Table 3.2: Summary of GHG emissions by category 1990-2020 [kt CO_2 eq.]

	1 Energy	2 IPPU	3 Agriculture	4 LULUCF	5 Waste
1990	161178.30	17250.05	15512.64	-8936.22	3014.26
1991	148313.49	13864.56	13392.82	-10326.37	3154.55
1992	144022.05	14647.52	11510.11	-10383.26	3139.93
1993	139187.44	13448.91	10255.40	-11067.82	3209.64
1994	130042.35	14735.00	9280.41	-9770.22	3340.40
1995	129378.50	14298.67	9317.00	-10037.56	3326.69
1996	131972.74	15104.35	9004.06	-9831.59	3352.44
1997	126752.02	16147.28	8631.79	-8847.92	3456.05
1998	120714.87	16347.01	8284.29	-8561.07	3563.61
1999	113602.33	13734.13	8316.72	-8719.96	3560.05
2000	122159.18	15347.04	8488.30	-9388.10	3599.85

	1 Energy	2 IPPU	3 Agriculture	4 LULUCF	5 Waste
2001	122481.27	14653.14	8838.00	-9303.44	3726.23
2002	119330.02	14439.51	8497.38	-9038.99	3830.09
2003	121897.00	15513.43	7860.61	-8443.93	3968.90
2004	121658.89	16488.58	8242.66	-8234.42	3912.52
2005	120865.45	15152.22	8123.81	-8339.70	3956.47
2006	120988.74	16273.71	8094.93	-7118.66	4013.50
2007	121842.55	17012.78	8338.71	-6515.07	3934.26
2008	116621.02	16944.58	8421.88	-7831.39	4120.75
2009	110679.38	14278.74	7573.17	-7714.89	4216.40
2010	112507.28	15112.90	7471.85	-7039.53	4457.84
2011	110029.72	15462.07	8127.02	-7357.46	4497.68
2012	106251.61	15229.89	8043.62	-7476.77	4650.92
2013	100882.42	15110.03	8013.04	-6832.28	4907.53
2014	97848.05	15894.00	8082.65	-6749.56	4903.55
2015	98861.90	15646.30	8667.76	-6678.37	4982.58
2016	100130.92	15742.92	8604.87	-5793.26	5016.48
2017	100940.81	16002.06	8562.43	-4115.57	5047.88
2018	98758.98	16558.20	8322.36	1407.52	5093.89
2019	93827.75	15867.68	8069.72	8235.29	5130.18
2020	84581.01	15229.96	7841.83	12771.80	5135.78
[1]%	**-9.86**	**-4.02**	**-2.82**	**55.09**	**0.11**
[2]%	**-47.52**	**-11.71**	**-49.45**	**-242.92**	**70.38**
[1] Difference relative to previous year					
[2] Difference relative to base year					

Source: CHMI

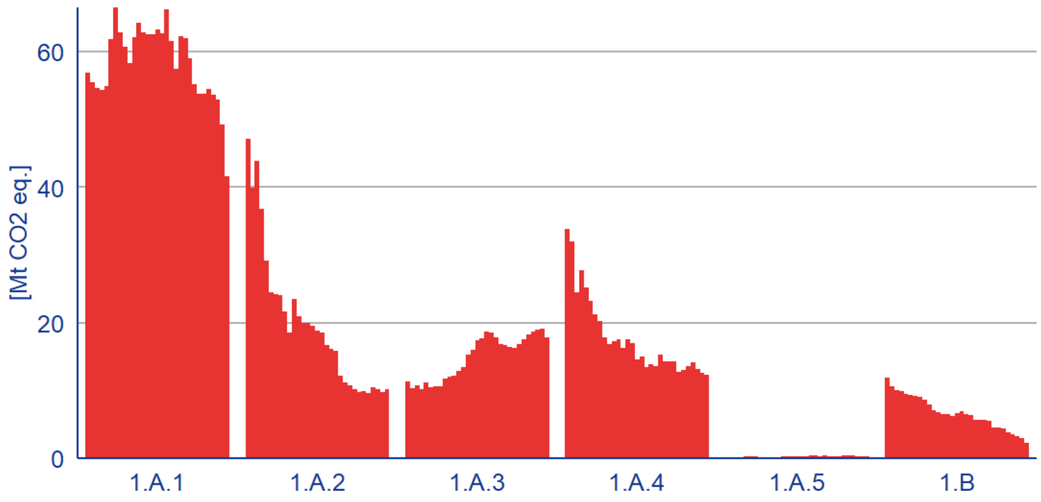
Energy (IPCC Category 1)

The trend for GHG emissions from 1 Energy category shows decreasing trend of emissions. They strongly decreased from 1990 to 1994 and then fluctuated by 2002. After 2002 they stayed relatively stable by 2007. In the period 2002 – 2007 emissions kept around 120 000 kt CO_2 eq. Total decrease between 1990 and 2020 is 47.52%. Between 2017 to 2020 emissions from category 1 Energy rapidly decreased by 16.21%.

From the total 84 581.01 kt CO_2 eq. in 2020 97% comes from 1.A Fuel Combustion, the rest are 1.B Fugitive Emissions from Fuels (mainly Solid Fuels). 1.B Fugitive Emissions from Fuels is the largest source for CH_4, which represented 20% of all CH_4 emissions in 2020. 28% of all CH_4 emissions in 2020 originated from Energy category.

CO_2 emissions from fossil fuels combustion (category 1.A Energy) are the main source in the Czech Republic's inventory with a share of 95% in total emissions from Energy sector. CO_2 emissions from category 1 Energy contributes for 72% to total GHG emissions, CH_4 for 3% and N_2O for 1% in 2020 (excl. LULUCF).

Figure 3.9: Trends in Energy by categories 1990–2020 (Mt CO_2 eq.)



Source: CHMI

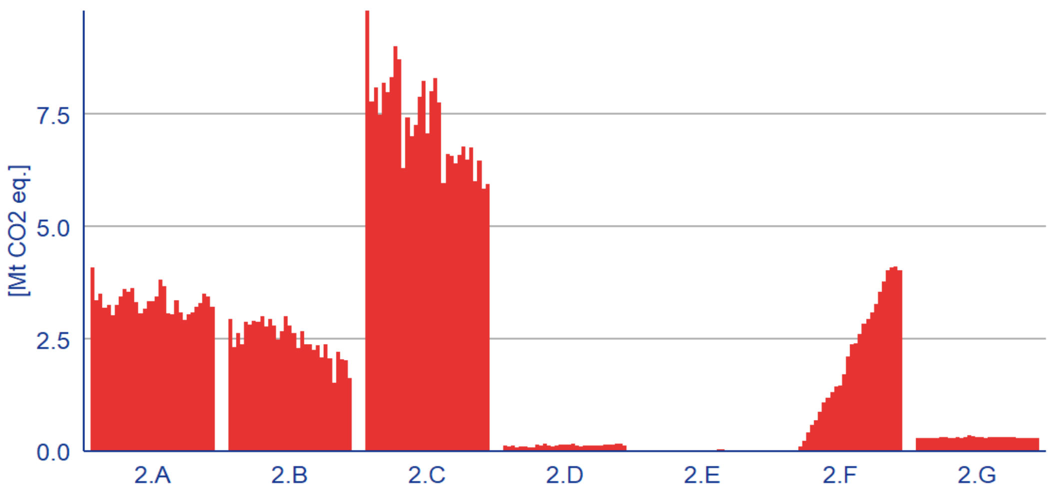
<u>Industrial Processes and Product Use (IPCC Category 2)</u>

GHG emissions from the 2 Industrial Processes and Product Use category fluctuated with decreasing trend during the whole period 1990 to 2020. In early 90's emissions decreased rather rapidly. They reached decade minimum in 1993 and since then they have fluctuated. By the end of noughties they reached their decade minimum due to global economic recession. Between 1990 and 2020, emissions from this category decreased by 11.71%. In 2020 emissions amounted for 15 229.96 kt CO_2 eq.

The main categories in the 2 Industrial Processes and Product Use category are 2.C Metal Industry (39%), 2.F Product Uses as ODS substitutes (26%), 2.A Mineral Industry (21%) and 2.B Chemical Industry (11%) of the sectoral emissions in 2020 (Fig. 2-6).

The most important GHG of the 2 Industrial Processes and Product Use category was CO_2 with 70% of sectoral emissions, followed by F-gases (27%).

Figure 3.10: Trends in IPPU by categories 1990–2020 (Mt CO_2 eq.)



Source: CHMI

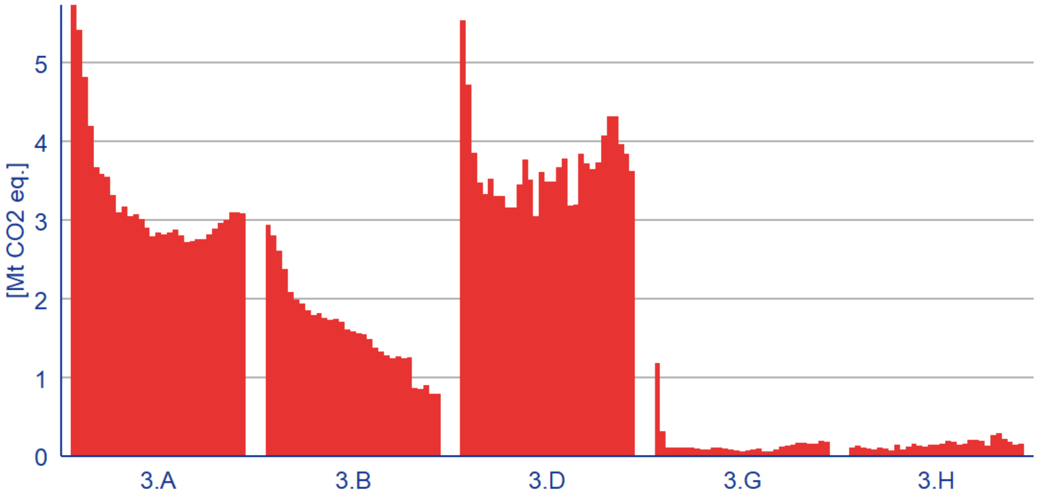
Agriculture (IPCC Category 3)

GHG emissions from the category 3 Agriculture decreased relatively steadily over the period from 1990 to 2003 and then fluctuated. In 2010 emissions reached minimum level which is 52 % below the base year level.

Agriculture amounted to 7 841.83 kt CO_2 eq. in 2020 which corresponds to 7% of national total emissions (excl. indirect emissions, excl. LULUCF). The most important sub-category 3.D Agricultural Soils (N_2O emissions) contributed by 46% to sectoral total in 2020, followed by the 3.A Enteric Fermentation (CH_4 emissions, 39%).

3 Agriculture is the largest source for N_2O and second largest source for CH_4 emissions (76% of total emissions of N_2O and 30% of total emissions of CH_4, excl. LULUCF). However it's emission trend steadily decreases over the whole observed period.

Figure: 3.11: Trends in Agriculture by categories 1990–2020 (Mt CO_2 eq.)



Source: CHMI

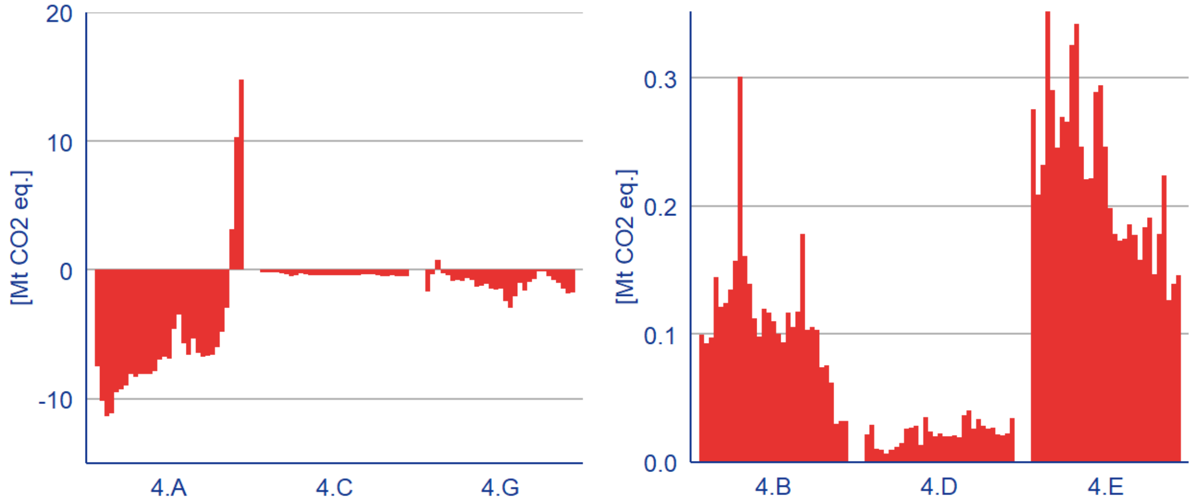
Land Use, Land-Use Change and Forestry (IPCC Category 4)

GHG removals from the 4 Land Use, Land-Use Change and Forestry category vary through the whole time series with maximum of -11 067.82 kt CO_2 eq. in 1993 and minimum in 2017 (-4 115.57 kt CO_2 eq.).

Emissions and removals amounted to 12 771.80 kt CO_2 eq. in 2020, which corresponds to 10% of total national emissions.

LULUCF category is no longer a sink for CO_2. Starting with 2015 the removals decreased and resulted in emissions since 2018. The situation is caused by the extreme drought-induced accelerating bark-beetle outbreak calamity experienced in the Czech forestry in the recent years (since 2015).

Figure 3.12: Trends in LULUCF by separate source and sink categories 1990–2020 (Mt CO_2 eq.)



Source: CHMI

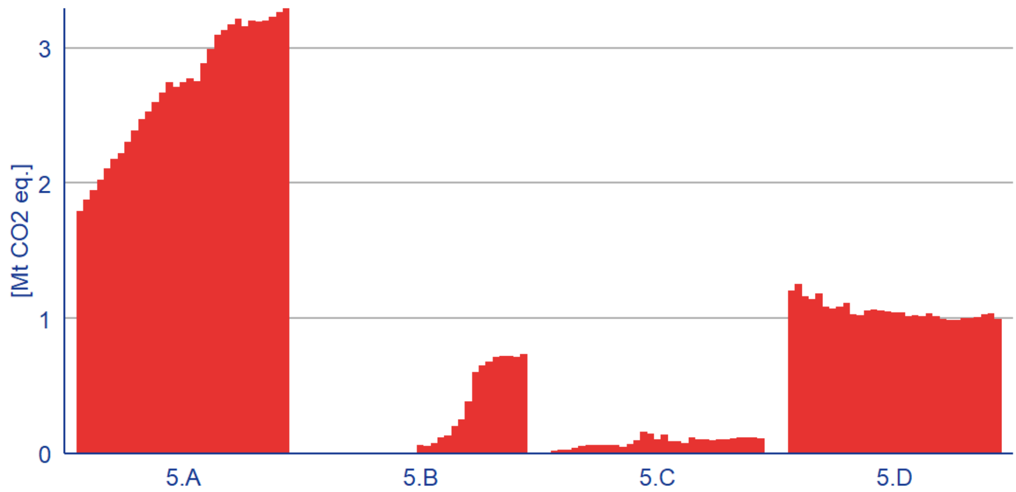
<u>Waste (IPCC Category 5)</u>

GHG emissions from category 5 Waste substantially increased during the whole period. In 2020 emissions amounted for 5 135.78 kt CO_2 eq., which is 70% above the base year level. The increase of emissions is mainly due to higher emissions of CH_4 from 5.A Solid Waste Disposal and due higher emissions in 5.B Biological treatment of solid waste. The share of category 5 Waste in total emissions was 5% in 2020.

The main source is 5.A Solid Waste Disposal, which accounted for 64% of sectoral emissions in 2020, followed by 5.D Wastewater Treatment and Discharge (19%) and 5.B Biological treatment of solid waste (14%). Trends of the separate sub-categories in Waste sector can be observed on Fig. 2-9.

93% of all emissions from Waste category are CH_4 emissions; CO_2 contributes by 2% and N_2O by 5%.

Figure 3.13: Trends in Waste by categories 1990–2020 (Mt CO_2 eq.)



Source: CHMI

3.3 National inventory arrangements

3.3.1 Introduction

The National Inventory System (NIS), as required by the *Kyoto Protocol* (Article 5.1) and by Regulation No. 525/2013/EC, has been in place since 2005. As approved by the *Ministry of Environment* (MoE), which is the single national entity with overall responsibility, the founder of CHMI and its superior institution.

The *Czech Hydrometeorological Institute* (CHMI), under the supervision of the *Ministry of the Environment*, is designated as the coordinating and managing organization responsible for the compilation of the national GHG inventory and reporting its results. The main tasks of CHMI consist in inventory management, general and cross-cutting issues, QA/QC, communication with the relevant UNFCCC and EU bodies, etc.

The objective of NIS is to ensure high-quality national inventory of GHGs so that it complies with all requirements whether imposed by relevant Decision or IPCC methodology. From practical point of view this means achieving required quality of national inventories, so that these pass regular international reviews.

3.3.2 Institutional Arrangements

Person responsible for international reporting on greenhouse gases:
Mr. Pavel Zámyslický, Director of Energy and Climate Protection Dept., Ministry of the Environment, pavel.zamyslicky@mzp.cz

Person responsible for compilation of the inventory:
Ms. Zuzana Rošková, NIS Coordinator, Czech Hydrometeorological Institute, zuzana.roskova@chmi.cz

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Since 2019 the National Inventory Team obtained higher funding from Ministry of Environment, which is further improving the cooperation with sectoral experts and sectoral institutions. Since 2015 the contracts with relevant sectoral institutions were signed for four years. Since previous years the contracts were signed only for one year. This step means significant strengthening of the National System.

In 2019 the NIS was broadened by including another two organisations, which are supporting the inventory in agriculture and LULUCF sectors. These are the Crop Research Institute and Global Change Research Institute of the Czech Academy of Sciences.

In 2022 there was a change in a position of NIS coordinator and a position of an IPPU expert. The inventory is now coordinated by Zuzana Rošková and Barbora Kočí is now responsible for the IPPU sector reporting.

A waste expert Jana Esterlová was replaced by Ivana Kopecká in 2022.

The Czech National Inventory Team hasn't undergone any further staffing change since last submission, the main pillars of the national inventory system declared in the Czech Republic's Initial Report under the Kyoto Protocol are operational and running.

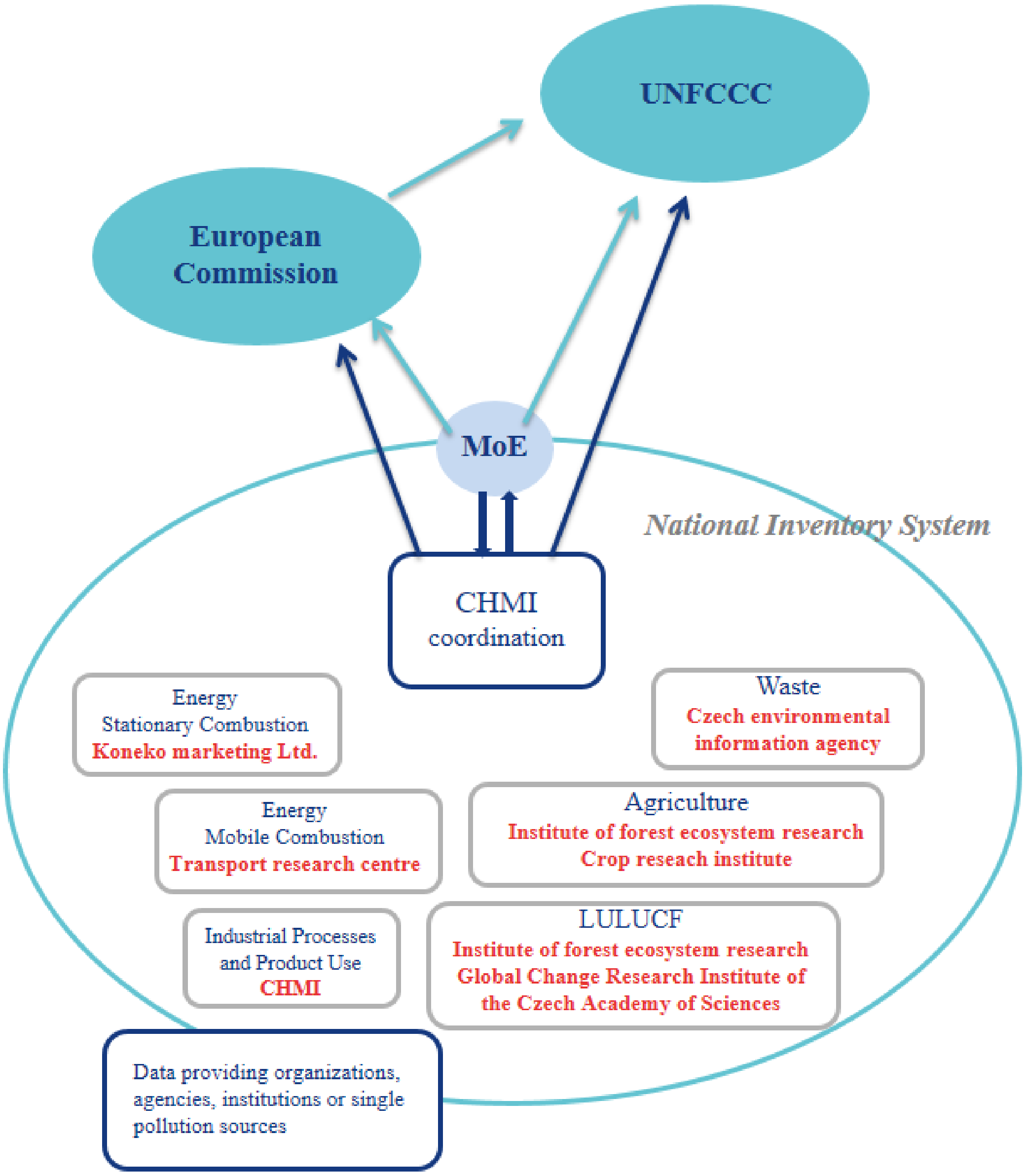
Sectoral inventories are prepared by sectoral experts from sector-solving institutions, which are coordinated and controlled by CHMI:

- KONEKO marketing Ltd. (KONEKO), Prague, is responsible for compilation of the inventory in sector 1. Energy, for stationary sources including fugitive emissions
- Transport Research Centre (CDV), Brno, is responsible for compilation of the inventory in sector 1. Energy, for mobile sources
- Czech Hydrometeorological Institute (CHMI), Prague, is responsible for compilation of the inventory in sector 2. Industrial Processes and Product Use
- Institute of Forest Ecosystem Research Ltd. (IFER), Jilove u Prahy, is responsible for compilation of the inventory in sectors 3. Agriculture and 4. Land Use, Land Use Change and Forestry
- Crop Research Institute (CRI), Prague, is co-responsible for compilation of the inventory in sector 3. Agriculture (IFER has the main responsibility)
- Global Change Research Institute of the Czech Academy of Sciences (GCRI), Brno, is co-responsible for compilation of the inventory in sector 4. Land Use, Land Use Change and Forestry (IFER has the main responsibility)
- Czech Environmental Information Agency (CENIA), Prague, is responsible for compilation of the inventory in sector 5. Waste.

One of the main pillars of NIS is allocation of responsibilities to institutions involved in inventory in individual sectors. The NIS Coordinator (CHMI) is primarily responsible for:

- Management (coordination of cooperation among individual sector agents)
- General and cross-section issues including determining the uncertainties
- QA/QC control procedures
- Data reporting in prescribed format - CRF (*Common Reporting Format*)
- Preparation of *National Inventory Report* (NIR)
- Cooperation with relevant UNFCCC and EU bodies
- Operation of complete archiving and documentation management system for the inventory.

Figure 3.14: Institutional arrangements of National Inventory System in the Czech Republic



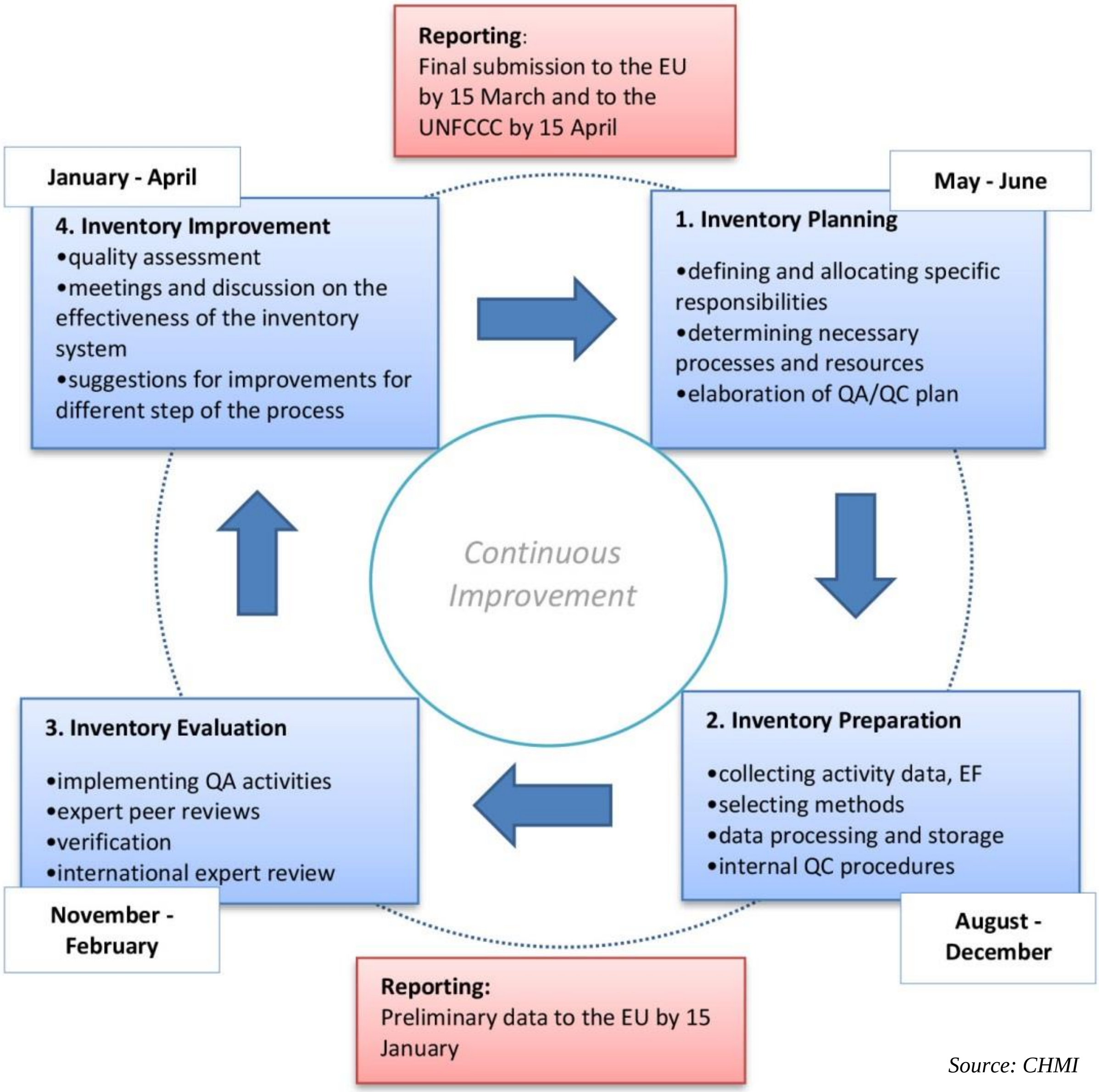
Source: CHMI

3.3.3 Inventory process

The annual inventory process describes at a general level how the inventory is produced by the national system. The quality of the output is ensured by the inventory experts in the course of compilation and reporting, which consist of four main stages: planning, preparation, evaluation and improvement (Figure 3.15). The quality control and quality assurance elements are integrated into the production system of the inventory; each stage of the inventory includes the relevant QA/QC procedures.

A clear set of documents is produced on the different work phases of the inventory. The documentation ensures the transparency of the inventory: it enables external evaluation of the inventory and, where necessary, its replication.

Figure 3.15: Time schedule of submissions and QA/QC procedures



Source: CHMI

3.3.4 Official inventory result approval process

Regarding the national GHG inventory submission to the UNFCCC (15 April), the same procedure will be applied as for the corresponding reporting to the EC. The following approval procedure is within the authorization of the Ministry of the Environment of the Czech Republic. The procedure involves that the report is sent by the Ministry of the Environment, well ahead via email, to the relevant ministries in the Czech Republic (e.g. Ministry of Finance, Ministry of Transport, Ministry of Foreign Affairs, Ministry of Education, Youth and Sports, etc.), organizations (e.g. Czech Environmental Inspectorate, Czech Environmental Information Agency, non-governmental organizations, etc.), as well as to the unions of different producers (e.g. Czech-Moravian Confederation of Trade Unions, Confederation of Industry of the Czech Republic, Association of Chemical Industry of the Czech Republic, Union of Czech and Moravian Production Co-operatives, Czech Cement Association, etc.) before the official submission to the UNFCCC for their comments and observations. This is the so called proceeding of external comments. Thereafter, comments and observations must be resolved by the Climate Change Department of the Ministry of the Environment in consultation with CHMI. Such procedure is in accordance with the Provision no. 11/06 of the Ministry of the Environment, regarding the procedure for preparation and hand-over of reporting information.

3.3.5 Methodological aspects

National inventory of greenhouse gases is based on the IPCC methodology and principles of good practice (IPCC 2006 Guidelines).

Inventory of greenhouse gas emissions is a multi-level process including data collection, estimating emission sources and sinks, controls and verification, determining uncertainties and reporting. The main phases of inventory are:

Data collection: Data collection is the most significant stage and in many cases it is the most difficult phase, directly affecting accuracy of emission determination. Methodological instructions require assessment as to the appropriateness of existing data sources, and potentially undertaking own emission measurements, or searching for new and more exact data sources.

Collection of activity data is based mainly on the official documents of the Czech Statistical Office (CzSO), which are published annually, where the Czech Statistical Yearbook is the most representative example. However for industrial processes, because of the Czech Act on Statistics, production data are not generally available when there are fewer than 4 enterprises in the whole country. In such cases, inventory compilers have to rely either on specific statistical materials edited by sectoral associations or, in some cases, inventory experts have to carry out the relevant inquiries. In a few cases, the Czech register of individual sources and emissions, called REZZO, is utilized as source of activity data.

Emission estimates from Sector 1.A Fuel Combustion Activities are based on the official Czech Energy Balance, compiled by the Czech Statistical Office. Data from the Czech Energy balance are processed both in the Reference Approach (TPES - primary sources data are used) and in the Sectoral Approach (data for fuel transformations and final consumptions). However, in the latter case, some additional data are required (e.g. data on transportation statistics).

Recently data from EU ETS system are used as well. For the purposes of Energy sector are these data used more for control purposes, more detailed information is given in relevant chapter for Energy sector. Furthermore, for the emission estimates in IPPU sectors are EU ETS data used in much higher extend. For some subcategories, e.g. Cement Production or Lime Production is these data used for the complete inventory; in the subcategories is EU ETS data used for improving emission factors and data. These improvements are listed in the Improvement Plan.

Determining uncertainties: This process provides valuable information for inventory compilers and for inventory users. Uncertainties must be defined for each separate category of sources, as well as for total emissions and their trends. The determination of uncertainties is one of the important principles of good practice as it helps inventory compilers to better focus on those categories that considerably contribute to larger uncertainty in emission estimates (including allocation of funding) and to gradual improvement of quality, respectively.

Identification of key categories: Good practice requires that key categories are identified. Key categories are important for use of development diagrams during selection of appropriate method, and the inventory coordinator seeks to apply more sophisticated higher tiers methods of inventory to these key categories.

QA/QC control procedures: The application of QA/QC processes represent an important phase in compiling the NIR. The QA/QC processes include planning, conducting controls and reviewing relevant documentation, verification of data and their review by independent providers. The correct application of QA/QC processes is also one of the good practice principles, allowing for the removal of potential errors and discrepancies.

Reporting inventory results: Reporting to the UNFCCC takes place annually on April 15. The documents submitted include:

- National Inventory Report
- Export of complete data inventory – in xml format
- CRF tables (Common Reporting Format)
- SEF tables (Standard Electronic Format)

Reporting to the European Commission takes place in two stages, first as of 15th January and the final version as of 15th March each year, reporting for the European Commission matches the extent and quality of the report for the UNFCCC.

The text below specifies some other tools ensuring the required quality of reporting:

Tier approach: Depending on the complexity of the calculation and types of emission factors used (generally recommended - *default*, country-specific, site-specific and technology-specific), the approaches described in the IPCC methodology consist of three tiers. Tier 1 is typically characterized by simpler calculations, based on the basic statistical data and on the use of generally recommended emission factors (*default*) of global or continental applicability, tabulated directly in above mentioned methodical manuals.

Tier 2 is based on sophisticated calculation and usually requires more detailed and less accessible statistical data. The emission factors (country-specific or technology-specific) are usually derived using calculations based on more complex studies and better knowledge of the source. Even in these cases, it is sometimes possible to find the necessary parameters for the calculation in IPCC manuals. Procedures in Tier 3 are usually considered to consist in procedures based on the results of direct measurements carried out under local conditions and locally parameterized models.

Methods of higher tiers should be applied mainly for key categories. Key categories (key source categories) are defined as categories that cumulatively contribute 90% or more to the overall uncertainty either in level or in trend. Apparently, procedures in higher tiers should be more accurate and should better reflect reality. However, they are more demanding in all respects, and especially they are more expensive.

Because of the above-described problems encountered in the application of the methods of higher tiers, these procedures have so far been introduced only for some key categories. For example, for combustion of fuels, country-specific factors are employed only for Brown/Hard

Coal, Brown Coal + Lignite, Bituminous Coal, Coking Coal, Gas Works Gas, Refinery Gas, LPG and Natural Gas, while the default emission factors are employed for the rest of the other fuels. For Bituminous Coal, Brown Coal + Lignite and Brown Coal Briquettes are used country specific oxidation factors as well. Similarly, for Industrial Processes, only the Tier 1 method is used for the production of iron and steel. In contrast, the methods of higher tiers and/or country-specific factors are employed far more frequently for other key categories.

Emission factors: As described above, continuous development of country specific emission factors is occurring. The choosing of emission factor and methodology for emission estimates is specific for each sector and category. For more information on emission factors and applied methodologies please see Chapters 3 to 9 of National Inventory Report submitted in April 2022 to the UNFCCC.

Key categories: The key categories concept lies in the identification of categories having significant impact on total national GHG emissions or which could contribute to uncertainties (trends) since 1990. Key categories contribute to the total uncertainty of emission estimate in an actual year or in determining trends. The key categories enjoy special attention while compiling the National Inventory, demanding more complex methods and a thorough application of QA/QC processes, and while conducting more rigorous methods in planning the inventory improvement. The prioritization of funding allocation is directly tied to the output of the key categories' analyses.

Adherence to good practice principles leads to achieving all required quality criteria, which include: transparency, completeness, consistency, comparability and accuracy.

Transparency: Transparency means transparent and clear documenting of applied processes, allowing the understanding of how the inventory was compiled and whether all relevant principles of good practice were taken into account.

Completeness: The national inventory must include all categories of sources and sinks of GHG emissions. Any missing categories must be clearly identified and an appropriate justification provided of why they could not be included in the inventory or what steps are being taken for their future inclusion.

Consistency: Ensuring consistency of time series is important for demonstrating credibility of trends. The methodological manual describes ways of ensuring this consistency. Inventory emissions for the entire period must be determined using identical methods and same or similar data sources. The time series should encompass development of emissions over time and not potential changes in methods applied during the monitored period.

Comparability: The national inventory of GHGs shall be compiled in a manner allowing comparison with inventories taken in other countries. This may be achieved by the application of unified IPCC methods, including identical classification of sources and sinks, the identification of key sources, prescribed manner of reporting, etc.

Accuracy: The national inventory should not be over or under-estimated. It is therefore necessary to avoid systematic mistakes in estimating emissions.

The driving forces in applying recalculations in the Czech greenhouse gas inventory are provided by the implementation of the guidance given in the IPCC 2006 Gl. (IPCC, 2006) and the recommendations from the UNFCCC inventory reviews. Recalculations of previously submitted inventory data are performed following the above-mentioned IPCC manuals only to improve the GHG inventory.

Even though a QA/QC system helps to eliminate potential error sources, it is sometimes necessary to make some revisions (called recalculations) under the following circumstances:

- An emission source was not considered in the previous inventory.
- A source/data supplier has delivered new data. This could be because the previous data were only preliminary data (by estimation, extrapolation) or because the method of data collection has been improved.
- Some errors in data transfer or processing have been identified: wrong data, unit-conversion, software errors, etc.
- Methodological changes - when a new methodology must be applied to fulfil the reporting obligations for one of the following reasons:
    - to decrease uncertainties,
    - an emission source becomes a key source,
    - consistent input data needed for applying the methodology is no longer accessible,
    - input data for more detailed methodology is now available,
    - the methodology is no longer appropriate.

3.3.6 Key categories

The IPCC 2006 Guidelines (IPCC, 2006) provides two approaches of determining the key categories (key sources). Key categories by definition contribute to 95% percent of the overall uncertainty in a level (in emissions per year) or in a trend. Approach 2 follows from this definition, and requires thorough analysis of the uncertainty and use of sophisticated statistical procedures and evaluation of sources in terms of the appropriate characteristics.

Table 3.3: Identification of key categories by level assessment (LA) and trend assessment (TA) for 2020 evaluated with LULUCF (Approach 2)

IPCC Source Categories	GHG	Cumulative Total (LA, %)	Cumulative Total (TA, %)	KC type
4.A.1 Forest Land remaining Forest Land	CO_2	29.23	46.23	LA, TA
5.A Solid Waste Disposal	CH_4	38.81	68.60	LA, TA
2.F.1 Refrigeration and Air conditioning	F-gases	46.73	62.71	LA, TA
1.A.1 Energy industries - Solid Fuels	CO_2	52.31	97.14	LA
4.G Harvested wood products	CO_2	57.20	85.70	LA, TA
2.C.1 Iron and Steel Production	CO_2	60.51	94.88	LA
1.A.3.b Road Transportation	CO_2	63.40	81.14	LA, TA
1.B.1.a Coal Mining and Handling	CH_4	66.28	55.07	LA, TA
5.B Biological treatment of solid waste	CH_4	69.03	76.96	LA, TA
3.D.1 Direct N_2O Emissions From Managed Soils	N_2O	71.66	99.63	LA
3.A Enteric Fermentation	CH_4	73.89	93.06	LA
5.D Wastewater treatment and discharge	CH_4	76.01	93.87	LA
1.A.2 Manufacturing Industries and Construction - Other Fossil Fuels	CO_2	77.62	84.31	LA, TA
1.A.4 Other Sectors - Biomass	CH_4	79.18	86.71	LA, TA
2.B.8 Petrochemical and Carbon Black Production	CO_2	80.73	91.44	LA
1.A.4 Other Sectors - Gaseous Fuels	CO_2	82.25	89.41	LA, TA
1.A.3.b Road Transportation	N_2O	83.75	87.64	LA, TA
1.A.4 Other Sectors - Solid Fuels	CO_2	85.11	74.30	LA, TA

IPCC Source Categories	GHG	Cumulative Total (LA, %)	Cumulative Total (TA, %)	KC type
1.B.2.b Fugitive Emissions from Fuels - Oil and Natural Gas - Natural Gas	CH_4	86.43	95.70	LA
3.D.2 Indirect N_2O Emissions From Managed Soils	N_2O	87.58	98.98	LA
4.C.2 Land converted to Grassland	CO_2	88.71	98.21	LA
3.B Manure Management	N_2O	89.51	88.52	LA, TA
4.E.2 Land converted to Settlements	CO_2	90.10	97.80	LA
1.A.4 Other Sectors - Solid Fuels	CH_4	90.70	82.76	TA
1.A.2 Manufacturing Industries and Construction - Solid Fuels	CO_2	93.75	79.46	TA
3.G Liming	CO_2	96.62	90.22	TA

Source: CHMI

Table 3.4: Identification of key categories by level assessment (LA) and trend assessment (TA) for 2020 evaluated without LULUCF (Approach 2)

IPCC Source Categories	GHG	Cumulative Total (LA, %)	Cumulative Total (TA, %)	KC type
5.A Solid Waste Disposal	CH_4	15.23	43.57	LA, TA
2.F.1 Refrigeration and Air conditioning	F-gases	27.82	15.72	LA, TA
1.A.1 Energy industries - Solid Fuels	CO_2	36.68	80.83	LA, TA
2.C.1 Iron and Steel Production	CO_2	41.93	95.24	LA
1.A.3.b Road Transportation	CO_2	46.53	66.78	LA, TA
1.B.1.a Coal Mining and Handling	CH_4	51.10	30.48	LA, TA
5.B Biological treatment of solid waste	CH_4	55.48	58.71	LA, TA
3.D.1 Direct N_2O Emissions From Managed Soils	N_2O	59.66	89.67	LA, TA
3.A Enteric Fermentation	CH_4	63.21	96.13	LA
5.D Wastewater treatment and discharge	CH_4	66.58	86.21	LA, TA
1.A.2 Manufacturing Industries and Construction - Other Fossil Fuels	CO_2	69.14	69.98	LA, TA
1.A.4 Other Sectors - Biomass	CH_4	71.62	74.89	LA, TA
2.B.8 Petrochemical and Carbon Black Production	CO_2	74.08	82.24	LA, TA
1.A.4 Other Sectors - Gaseous Fuels	CO_2	76.49	78.93	LA, TA
1.A.3.b Road Transportation	N_2O	78.87	76.95	LA, TA
1.A.4 Other Sectors - Solid Fuels	CO_2	81.04	53.24	LA, TA
1.B.2.b Fugitive Emissions from Fuels - Oil and Natural Gas - Natural Gas	CH_4	83.13	98.86	LA
3.D.2 Indirect N_2O Emissions From Managed Soils	N_2O	84.98	96.86	LA
3.B Manure Management	N_2O	86.25	84.94	LA, TA
1.A.4 Other Sectors - Solid Fuels	CH_4	87.19	72.67	LA, TA
1.A.2 Manufacturing Industries and Construction - Gaseous Fuels	CO_2	88.11	92.17	LA
1.A.1 Energy industries - Solid Fuels	N_2O	88.94	97.60	LA
5.D Wastewater treatment and discharge	N_2O	89.75	95.56	LA
2.G Other Product Manufacture and Use	N_2O	90.46	94.88	LA
1.A.2 Manufacturing Industries and Construction - Solid Fuels	CO_2	91.15	63.00	TA
3.B Manure Management	CH_4	92.31	87.29	TA
1.A.4 Other Sectors - Liquid Fuels	CO_2	92.88	90.19	TA
3.G Liming	CO_2	95.19	83.61	TA
1.A.2 Manufacturing Industries and Construction - Liquid Fuels	CO_2	97.71	88.23	TA
2.B.2 Nitric Acid Production	N_2O	98.98	88.98	TA

Source: CHMI

Table 3.5: Identification of key categories by level assessment (LA) and trend assessment (TA) for 2020 evaluated with LULUCF (Approach 1)

IPCC Source Categories	GHG	Cumulative Total (LA, %)	Cumulative Total (TA, %)	KC type
1.A.1 Energy industries - Solid Fuels	CO_2	28.30	88.45	LA, TA
1.A.3.b Road Transportation	CO_2	41.42	64.32	LA, TA
4.A.1 Forest Land remaining Forest Land	CO_2	53.10	23.44	LA, TA
1.A.4 Other Sectors - Gaseous Fuels	CO_2	58.43	73.16	LA, TA
2.C.1 Iron and Steel Production	CO_2	62.95	93.35	LA, TA
1.A.2 Manufacturing Industries and Construction - Gaseous Fuels	CO_2	67.25	86.09	LA, TA
2.F.1 Refrigeration and Air conditioning	F-gases	70.29	76.87	LA, TA
1.A.1 Energy industries - Gaseous Fuels	CO_2	73.05	82.40	LA, TA
1.A.2 Manufacturing Industries and Construction - Solid Fuels	CO_2	75.65	42.47	LA, TA
5.A Solid Waste Disposal	CH_4	78.16	84.36	LA, TA
3.A Enteric Fermentation	CH_4	80.51	89.14	LA, TA
1.A.4 Other Sectors - Solid Fuels	CO_2	82.81	54.64	LA, TA
3.D.1 Direct N_2O Emissions From Managed Soils	N_2O	84.93	99.60	LA
2.A.1 Cement Production	CO_2	86.37	97.92	LA
4.G Harvested wood products	CO_2	87.69	94.37	LA, TA
1.B.1.a Coal Mining and Handling	CH_4	88.95	69.22	LA, TA
1.A.4 Other Sectors - Liquid Fuels	CO_2	89.90	87.27	LA, TA
2.B.8 Petrochemical and Carbon Black Production	CO_2	90.54	96.20	LA
3.D.2 Indirect N_2O Emissions From Managed Soils	N_2O	91.18	99.34	LA
5.D Wastewater treatment and discharge	CH_4	91.78	98.44	LA
5.B Biological treatment of solid waste	CH_4	92.29	91.01	LA, TA
1.A.4 Other Sectors - Biomass	CH_4	92.79	95.67	LA
2.A.2 Lime Production	CO_2	93.28	97.71	LA
1.A.2 Manufacturing Industries and Construction - Other Fossil Fuels	CO_2	93.73	93.89	LA, TA
4.A.2 Land converted to Forest Land	CO_2	94.17	95.92	LA
1.B.2.b Fugitive Emissions from Fuels - Oil and Natural Gas - Natural Gas	CH_4	94.61	98.55	LA
2.A.4 Other Process Uses of Carbonates	CO_2	95.01	95.26	LA, TA
1.A.2 Manufacturing Industries and Construction - Liquid Fuels	CO_2	95.38	79.85	TA
3.B Manure Management	N_2O	95.72	94.83	TA
3.B Manure Management	CH_4	96.27	89.78	TA
1.A.1 Energy industries - Liquid Fuels	CO_2	96.54	90.40	TA
1.A.4 Other Sectors - Solid Fuels	CH_4	97.57	91.63	TA
3.G Liming	CO_2	98.34	92.78	TA
2.B.2 Nitric Acid Production	N_2O	99.40	92.21	TA

Source: CHMI

Table 3.6: Identification of key categories by level assessment (LA) and trend assessment (TA) for 2020 evaluated without LULUCF (Approach 1)

IPCC Source Categories	GHG	Cumulative Total (LA, %)	Cumulative Total (TA, %)	KC type
1.A.1 Energy industries - Solid Fuels	CO_2	32.93	57.21	LA, TA
1.A.3.b Road Transportation	CO_2	48.19	35.67	LA, TA
1.A.4 Other Sectors - Gaseous Fuels	CO_2	54.40	63.01	LA, TA
2.C.1 Iron and Steel Production	CO_2	59.65	95.78	LA
1.A.2 Manufacturing Industries and Construction - Gaseous Fuels	CO_2	64.66	83.35	LA, TA
2.F.1 Refrigeration and Air conditioning	F-gases	68.19	73.39	LA, TA
1.A.1 Energy industries - Gaseous Fuels	CO_2	71.40	76.98	LA, TA
1.A.2 Manufacturing Industries and Construction - Solid Fuels	CO_2	74.42	21.39	LA, TA

IPCC Source Categories	GHG	Cumulative Total (LA, %)	Cumulative Total (TA, %)	KC type
5.A Solid Waste Disposal	CH_4	77.34	86.21	LA, TA
3.A Enteric Fermentation	CH_4	80.09	97.70	LA
1.A.4 Other Sectors - Solid Fuels	CO_2	82.75	49.19	LA, TA
3.D.1 Direct N_2O Emissions From Managed Soils	N_2O	85.22	94.91	LA, TA
2.A.1 Cement Production	CO_2	86.90	93.37	LA, TA
1.B.1.a Coal Mining and Handling	CH_4	88.36	68.38	LA, TA
1.A.4 Other Sectors - Liquid Fuels	CO_2	89.47	87.35	LA, TA
2.B.8 Petrochemical and Carbon Black Production	CO_2	90.22	94.44	LA, TA
3.D.2 Indirect N_2O Emissions From Managed Soils	N_2O	90.96	98.81	LA
5.D Wastewater treatment and discharge	CH_4	91.66	96.40	LA
5.B Biological treatment of solid waste	CH_4	92.25	88.18	LA, TA
1.A.4 Other Sectors - Biomass	CH_4	92.83	92.79	LA, TA
2.A.2 Lime Production	CO_2	93.41	98.23	LA
1.A.2 Manufacturing Industries and Construction - Other Fossil Fuels	CO_2	93.92	88.91	LA, TA
1.B.2.b Fugitive Emissions from Fuels - Oil and Natural Gas - Natural Gas	CH_4	94.44	99.77	LA
2.A.4 Other Process Uses of Carbonates	CO_2	94.91	93.96	LA, TA
1.A.2 Manufacturing Industries and Construction - Liquid Fuels	CO_2	95.34	80.34	LA, TA
3.B Manure Management	N_2O	95.72	95.37	TA
3.B Manure Management	CH_4	96.37	89.59	TA
1.A.1 Energy industries - Liquid Fuels	CO_2	96.68	91.57	TA
1.A.4 Other Sectors - Solid Fuels	CH_4	97.60	90.25	TA
3.G Liming	CO_2	98.34	92.20	TA
2.B.2 Nitric Acid Production	N_2O	99.44	90.92	TA

Source: CHMI

On the whole, 34 (Approach 1) and 30 (Approach 2) key categories were identified either by level assessment or by trend assessment. A summary of the assessed numbers concerning key categories is given in Table 3.7.

Table 3.7: Figures for key categories assessed

	Approach 1	Approach 2
Key categories (KC) with LULUCF	34	26
KC identified by LA	27	23
KC identified by TA	25	16
KC identified by LA + TA concurrently	18	13
KC identified by only LA	9	10
KC identified by only TA	7	3
Key Categories (KC) without LULUCF:	31	30
KC identified by LA	25	24
KC identified by TA	25	22
KC identified by LA + TA concurrently	19	16
KC identified by only LA	6	8
KC identified by only TA	6	6

Source: CHMI

3.3.7 *Inventory uncertainties*

The determination of uncertainties is one of the most important principles of good practice in the emission inventory. Uncertainty analysis characterizes the extent (i.e. possible interval) of results for the entire national inventory and for its individual components. Knowledge of the individual and overall uncertainties enables compilers of emission inventories better understanding of the inventory process, which encompasses collection of suitable input data and their evaluation. Uncertainty analysis also help in identifying those categories of emission sources and sinks that contribute most to the overall uncertainty and thus establish priorities for further improvement of the quality of the data.

A method of uncertainty determination based on the error propagation method (Tier 1), using calculation sheets obtained according to the prescribed methodology (IPCC, 2006), has been used in the Czech national inventory for a number of years. The accuracy of the calculation algorithm has been sufficiently verified, uncertainty in the activity data and emission factors for the individual categories are updated every submission. Experts from CHMI and all the contributing sectoral organizations are participating in this work. The individual experts investigated the uncertainty parameters coming under their field of work and proposed new ones or defended the original ones in discussions.

Uncertainty analysis of Tier 1, which is presented in current volume of NIR, employs the same source categorization as used in key categories assessment. Actual results of the uncertainty analysis for 2020 after above mentioned revision of the input parameters are given in Annex 2 of the NIR.

Further, uncertainty bases are yearly evaluated for LULUCF, Waste and Energy sector, which are then used for the overall uncertainty analysis.

Results of uncertainty assessment were obtained (i) for all sectors including LULUCF and (ii) for comparison also for all sectors without LULUCF. The estimated overall uncertainty in level assessment (case with LULUCF) reached 5.63%. The corresponding uncertainty in trend is 3.40%. For the case without LULUCF the estimated overall uncertainty in level assessment is 3.11% and 1.94% in trend.

The same source categories used in key sources assessment have also been used even in uncertainty analysis. In this way, the uncertainty analysis result was used later in Approach 2 key source analysis.

3.3.8 *QA/QC control procedures*

The QA/QC processes are carried out annually pursuant to an updated plan. The plan preparation reflects institutional arrangements: Each institution prepares its own QA/QC procedures, including the authorization of responsible QA/QC expert for each sector. The sector QA/QC plan is an integral part of the entire QA/QC plan, which is prepared by a QA/QC manager. The national inventory of GHGs is a part of client processes at the CHMI following the ISO 9001 quality standard (CHMI obtained certification). The processes relating to national inventory are elaborated in the form of development diagrams and include all main principles that need to be adhered to during the compilation of the inventory including the QA/QC processes.

QC processes include routine technical inspections of inventory quality to ensure consistency, integrity, accuracy, and completeness of the data and to reveal and remove any error and omissions. The QC processes are applied to all fundamental processes carried out during the inventory: Data collection, selection of appropriate method and emission factors, and calculations of emissions and processes documentation. These QC procedures are carried out in line with the IPCC methodology (IPCC, 2006). Sector compilers undertake parts of these processes; the rest is carried out by the NIS coordinator. The sector compilers focus primarily on activity data control, emission factors, and applied sector-specific methods, the NIS coordinator reviews the appropriateness of method selection, and analyses trends and compares data from several possible sources. The sector compilers and the NIS coordinator use control tools available in the CRF Reporter.

The QA processes include control activities and reviews by third parties not directly involved in the national inventory compilation, but rather competent experts in the given field. The CHMI cooperates on the QA processes with Slovak experts from the Slovak Hydrometeorological Institute (SHMI), who are involved in the preparation and compilation of the Slovak national inventory. Also, the QA cooperation was broadened five year ago by including in the processes experts from the Hungarian and Polish national inventory teams.

The regular international inspections undertaken by the UNFCCC play a significant role in increasing the quality of the national inventory. The inspections identify shortcomings and provide recommendations that are thoroughly analysed by the Czech NIS team; inspection conclusions are used to improve the quality of the Czech national inventory.

A detailed QA/QC management explanation is provided in the NIR in chapter 1.2.3.

3.3.9 Systematic improvement of inventory quality

Plan for improvement of inventory quality also constitutes one of the good practice tools besides being one of the fundamental provisions of the Kyoto Protocol (KP) (Art.10, para a-f). The National inventory system has drafted and annually updates improvement plan for the existing inventory system. One of the basic tools for this planning is, among other, analysis of key categories.

The improvement plan is yearly evaluated and updated. Focus on the improvement is on key categories, as well as on the development of country specific emissions factors and other necessary computational factors. Important part of the improvement plan are annual reviews held by UNFCCC and EU.

For further details please consult Chapter 10 of the National Inventory Report submitted in April 2022 to the UNFCCC.

3.3.10 Systematic Minimization of adverse impacts and effects under articles 3.14 and 2.3 of the Kyoto Protocol / Information on assessment of consequences of response measures

For information on Minimization of Adverse Impact see Chapter 16 of the National Inventory report submitted in April 2022 to the UNFCCC. More information on the EU-wide assessment procedures is available in section 4 of the EU 5th Biennial Report.

3.3.11 National emission trading registry

The European Union Emissions Trading Scheme (EU ETS) has been established by Directive 2003/87/EC, as amended. The EU ETS has been a part of the Kyoto Protocol (KP) since 2008. According to the Commission Regulation (EU) No. 389/2013 of 2 May 2013 establishing a Union Registry pursuant to Directive 2003/87/EC, as amended, each Member State is obliged to use the single EU registry which functions as KP registry.

The national registry has been operated since 2005 by OTE, corp., company on the basis of authorization issued by the Ministry of the Environment. The single EU registry was fully implemented in June 2012. Only duly authorized representatives of account holders can access the registry.

The registry serves to provide accurate evidence of issuance, holding, transfers and cancellations of allowances. EU ETS allowances and Kyoto units are recorded in individual accounts of the parties, operators' accounts, aircraft operators' accounts, trading accounts or personal accounts. According to Act No. 383/2012 Coll. on conditions of trading with greenhouse gas emission allowances, as amended, all facility operators holding Ministry of the Environment permit to discharge greenhouse gases into air, have the obligation to establish an account in the registry. Since January 2012, the same obligation is imposed on aircraft operators with operating license issued in the Czech Republic or who fall under the Czech administration pursuant to the list of aircraft operators issued by the EC. Trading account or personal account may be opened by any natural or legal entity including facility of (aircraft) operators, who already have an operator's account.

OTE, corp., company as the administrator of the Registry operates an internet emission trading portal at https://www.povolenky.cz/

Contact information:
OTE, crop. (Czech electricity and gas market operator)
Sokolovská 192/79, 186 00 Prague 8 – Karlín
Telephone: +420 296 579 329
Fax: +420 296 579 180
e-mail: povolenky@ote-cr.cz

The EU Member States, which are also Parties to KP, including also Iceland, Lichtenstein and Norway have decided to operate national registry in consolidated form in line with all relevant decisions applicable to Parties' registries – namely Decision 13/CMP.1 and 24/CP.8. Consolidated platform implementing national registries (including EU registries) is called CSEUR - Consolidated System of EU Registries).

In 2012, the EU registry underwent fundamental change / development in line with new requirements laid down by Commission Regulation 920/2010 and Commission Regulation 1193/2011 and in line with CSEUR implementation. Both regulations are now replaced by Commission Regulation (EU) No. 389/2013. Transfer to the Consolidated System of EU Registries initiated changes in security system and control systems and in minimizing of discrepancies during manipulation with individual unit types (ERU, CER, tCER, lCER, AAU, RMU).

Complete description of functionalities and technical details of consolidated registries have been provided to UNFCCC within the framework of common/specific readiness documentation of EU national registries and all consolidated national registries. The overview of security measures, list of publicly accessible information and description of disaster recovery plan is provided in Chapter 15.2 of the National Inventory Report (NIR), which was submitted to the secretariat of the UNFCCC in April 2022, and separate annexes referenced in Chapter 15.2 which were submitted together with NIR.

4 POLICIES AND MEASURES, LEGISLATION AND PROGRAMMES WITH IMPACT ON GREENHOUSE GAS EMISSIONS REDUCTION

4.1 System of climate policies and legislation

4.1.1 Climate policy development

The Ministry of the Environment is responsible for the compliance with the UNFCCC, the Kyoto Protocol and the Paris Agreement in the Czech Republic; the Ministry of the Environment is also the supreme State administration body in the area of environmental protection. The climate change agenda is addressed primarily within the Department of Energy and Climate Protection which also serves as a National Focal Point for the Convention, Protocol and the Paris Agreement in the Czech Republic. Having in mind the cross-sectoral nature of climate change issues, which affects many other departments, the Ministry of the Environment is responsible primarily for the drafting of national policies in areas of mitigation and adaptation. Individual State departments (Ministries), such as Ministry of the Environment, Ministry of Industry and Trade, Ministry of Transport, Ministry of Agriculture, Ministry of Regional Development etc. are then responsible for drafting and implementation of sector-specific policies and measures aiming to reduce emissions of greenhouse gases and/or adapt to climate change impacts, according to the nature of measure.

4.1.2 National and regional programmes, legislative tools and administrative procedures

With regard to the size of the Czech Republic, arrangement of its State administration and division of powers between central and regional bodies pursuant to Act No. 129/2000 Coll., on Regions, as amended, the Regions do not have a direct competence in the area of protection of global climate system. Nevertheless, the Regional bodies remain responsible, pursuant to Section 1 and 14 of Act No. 129/2000 Coll., on Regions, as amended, for overall development of its territory and for addressing the needs of its population in general terms. This is the foundation of the regional role of responsible bodies in creation of Regional development concepts and plans including water management plans for river basins and flood prevention measures, principles of territorial development including use of renewable energy sources (RES). Regional bodies are also involved in implementation of the below specified energy savings programmes and use of RES, restoration of housing fund (central heating supply systems, revitalization of housing estates) and improvement of transportation infrastructure. Regions also play a large role in preparation of waste management plans and in actual waste management (operation of landfills, composting facilities, facilities involved in energy and material recovery of waste etc.).

Measures of a legislative nature play an important role in the Czech Republic, not only imposing a number of obligations on the state administration and also natural and legal persons, but also providing for the preparation and revision of important strategic documents and programmes.

Since 2000, an integrated and complex system of strategic and operational planning has gradually been created, which is further modified in line with different international commitments of the Czech Republic whether assumed pursuant to post-Kyoto processes or EU policies and legislation. Legislative measures also lay down rules for institutional responsibilities for coordination and implementation of various programmes and impose obligations for their regular evaluation.

Wider strategic framework is created primarily by the following documents:

- Czech Republic 2030 (adopted by the Czech Government in 2017),
- National Reform Programme (updated annually, last update in 2022),
- Strategy of the Regional Development 2021+ (adopted in 2019).

The most important strategic documents with direct or demonstrable indirect effect on greenhouse gas emissions:

- State Environmental Policy of the Czech Republic 2030 with a view to 2050
- Climate Protection Policy of the Czech Republic
- National Emission Reduction Programme
- National Energy and Climate Plan of the Czech Republic
- Strategy on Adaptation to Climate Change in the Czech Republic
- National Action Plan on Adaptation to Climate Change
- State Energy Policy
- National Action Plan for Clean Mobility
- Waste Management Plan 2015 – 2024
- The Czech Recovery and Resilience Plan

4.2 Cross-cutting policies and measures

4.2.1 Climate Protection Policy of the Czech Republic

The Policy defines GHG reduction targets for 2020 and 2030. It also includes indicative trajectories and objectives for 2040 and 2050. Further, 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 in 2023.

The Government adopted the Climate Protection Policy of the Czech Republic in March 2017 and this document replaced the National Programme to Abate the Climate Change Impacts in the Czech Republic (2004). This Policy reflects significant recent developments at the EU, international and national level. The long-term perspective for gradual transition to low emission development until 2050 was included in such governmental document for the first time. The Strategic Impact Assessment of the Policy was carried out and completed with an affirmative statement in January 2017.

The Climate Protection 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.

The Policy also outlines some economic aspects for the greenhouse gas reductions on the national level. The European structural and investment funds represent the main source of financing in the programming period of 2014-2020. Another key financial source is represented by the auction revenues generated by the EU ETS. The Policy was evaluated in 2021 and based on this evaluation the Policy will be updated by 2023 to reflect the news Fit for 55 package and the target of climate neutrality of the EU by 2050.

Type of policy: Regulatory

Implementing entity: Ministry of the Environment (Government)

Period of implementation: 2017-2030

Implemented in scenario: WEM

Mitigation impact: The policy is a framework measure, therefore its mitigation effects is accounted under other specific measures.

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

Sectors: Energy, Transport, Industrial Processes, Agriculture, LULUCF, Waste, Cross-cutting

Greenhouse gas coverage: CH_4, CO_2, N_2O, SF_6, NF_3

4.2.2 European Union Emission Trading System (EU ETS)

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 the 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 legal system by Act No. 383/2012 Coll. on conditions for trading of emission allowances amending Acts No. 695/2004 Coll. and No. 164/2010 Coll. The Act 383/2012 was amended to transpose the revised Directive 2003/87/EC which sets rules for the new trading period 2021-2030.

Type of policy: Economic

Implementing entity: Ministry of the Environment (Government)

Period of implementation: 2005-2040

Implemented in scenario: WEM

Timeframe: Three trading periods of the EU ETS have been agreed. During the first (2005–2007) and the second (2008–2012) period, allowances were 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 focused 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 again a surplus of unused allowances. The aviation sector was brought into the EU ETS on January 1st 2012 through legislation adopted in 2008.

Some work on legislation accompanying the revised Directive 2003/87/EC has been finalized – that includes delegated regulation determining the free allocation rules, regulation on the

Innovation Fund and decision determining the sectors deemed to be at risk of carbon leakage. Other implementing legislation, such as detailed rules for the Modernization Fund, an EU-wide fund that will support investments in modernizing the power sector and energy efficiency, is currently under development.

As mentioned above, In the Czech Republic, the EU ETS is controlled via Act No. 383/2012 Coll., on conditions of trading with greenhouse gas emission allowances. This Act defines what facilities are subject to the system and the rights and obligations of operators. Operators monitor their emissions, report to the Ministry of the Environment and receive allowances. Part of the allowances is allocated free of charge; the remainder may be bought at the marketplace or in auctions. Allowances exist and can be transferred between allowance accounts within the registry, which is administered by the Czech electricity and gas market operator OTE, a.s.

In 2020, approximately 240 facilities participated in the system. The volume of emissions covered by the trading system in the Czech Republic represented approximately 51% of total greenhouse gas emissions in the Czech Republic in 2019. Monitored greenhouse gases include CO_2 and N_2O.

Allocation plan represented the required premise before initiation of allowance trading in the first two trading periods. The NAP determines the quantity of allowances, which are to be distributed during the trading period to individual facility operators. The Ministry of the Environment has prepared the NAP in cooperation with the Ministry of Industry and Trade. The NAP2 (2008-2012) allocation plans covered the first Kyoto Protocol commitment period and directly followed NAP1 (2005-2007) created for the first trading period. When calculating the allocated volume of allowances, the Ministry of the Environment based its estimates on historical, only partially verifiable emissions between 2000 and 2004 (which means that the quality and availability of data for the preparation of NAP1 was limited) and on fully verified emissions for the period covering 2005 and 2006 (for NAP2). The third trading period 2013-2020 uses National Allocation Tables instead of NAP and these tables determine allocation per facility for each year according to benchmarks.

In case of NAP2 (2008-2012), the total level of allocation in the Czech Republic was decided on the 26th of March 2007 by the European Commission, which allocated 86.8 million allowances in average annually to the Czech Republic. This allocated volume includes a reserve for new entrants in the amount of 1.29 million allowances and a reserve for joint implementation (JI) projects amounting to 99 389 allowances.

In 2020, facilities covered by the EU ETS emitted 54.68 million t CO_2 eq. In comparison with 2005, there has been a reduction of emissions by 33.7%,. The Table 4.1 below shows verified emissions from individual activities and their share in total GHG emissions.

Table 4.1: EU ETS verified emissions 2005-2020 [kt CO_2 eq.]

Activity/year	2005	2010	2015	2016	2017	2018	2019	2020
Combustion facilities	64.78	62.52	53.63	54.20	53.88	53.22	49.28	41.96
Refineries of mineral oils	1.00	1.05	0.93	0.71	1.00	0.92	0.98	0.80
Raw iron or steel	9.81	6.08	5.70	6.06	5.45	5.79	5.29	5.36
Production of coke	0.25	0.17	0.10	0.11	0.12	0.12	0.12	0.12
Production and processing of ferrous metals	0.07	0.10	0.11	0.10	0.10	0.10	0.09	0.09
Secondary aluminium	0.00	0.00	0.02	0.02	0.02	0.02	0.02	0.02

Cement and lime	3.85	3.35	3.46	3.70	3.82	4.15	4.14	3.92
Manufacture of glass	0.81	0.67	0.72	0.73	0.75	0.74	0.73	0.72
Production of ceramic	0.73	0.41	0.38	0.40	0.41	0.42	0.45	0.41
Production of mineral wool	0.00	0.04	0.06	0.06	0.06	0.06	0.05	0.05
Production of pulp	0.09	0.07	0.02	0.02	0.02	0.01	0.02	0.02
Production of paper or cardboard	0.64	0.58	0.46	0.45	0.44	0.46	0.51	0.49
Chemical industry	0.43	0.54	1.00	0.92	0.84	0.80	0.75	0.64
Other	0.00	0.00	0.06	0.06	0.07	0.09	0.08	0.07
Total CO_2 eq EU ETS emissions	82.45	75.58	66.65	67.53	66.98	66.91	62.52	54.68
Total CO_2 eq emissions (without LULUCF)	147.73	139.61	127.97	129.58	130.46	128.55	122.64	113.34
Share of CO_2 eq EU ETS emissions in total emissions [%]	55.82	54.14	52.08	52.11	51.34	52.05	50.98	48.24

Source: MoE

It remains difficult to quantify the EU ETS effect on the development of emissions due to the fact that besides the EU ETS, companies are influenced also by developments in fuel prices or electricity and general economic development.

The Directive 2009/29/ES of the European Parliament and of the Council of 23 April 2009 amending Directive 2008/101/EC of the European Parliament and of the Council of 19 November 2008 amending Directive 2003/87/EC included aviation activities in the scheme for greenhouse gas emission allowance trading within the Community. The new Directive, approved by decision of the Council 94/69/ES, reflecting the ultimate goal of UNFCCC i.e. to reach a stable concentration of GHG in atmosphere on the level which will prevent dangerous disruption of global climate system, should improve and extend the system of GHG´s emissions trading within the Community. The new Act 257/2014 Coll., which amended Act No. 383/2012 Coll. transposes the Directive 2009/29/ES into the Czech legal system.

Originally, the EU ETS was designed to cover all flights performed to/from and within the airports in the European Economic Area[11]. However, the Regulation (EU) No 421/2014 of the European Parliament and the Council limited the geographical scope of the EU ETS to intra-European Economic Area flights only for the 2013–2016 period. The main reason of limiting the EU ETS scope was to progress negotiation within the framework of International Civil Aviation Organization (ICAO) on development of the Global Market Based Measures to reduce international aviation emissions, which was finally concluded at the 39th ICAO Assembly (September 2016, Montreal).

The rules of the European Union applicable for monitoring, reporting and verification of aviation emissions are mainly contained in Directive 2003/87/EC of the European Parliament and in the Council and Commission Delegated Regulation (EU) 2019/1603 supplementing Directive 2003/87/EC. That Directive is the legal basis for the detailed provisions in this matter, contained in Commission Regulation (EU) 601/2012 and in Commission Implementing Regulations (EU) 2018/2066 and 2018/2067.

[11] The European Economic Area is the area in which the Agreement on the European Economic Area provides for the free movement of persons, goods, services, and capital within the European Single Market. It covers EU Member States and Norway, Iceland and Lichtenstein.

In general, there are two trading periods for the aviation sector in EU ETS. The first period was the year 2012 only. The second trading period is already harmonized with the third trading period for stationary sources (2013-2020). The volume of European emission allowances (EUAA) in the 1st trading period was determined at 97% of historic emissions (average emissions in the EU between 2004 and 2006). In the second trading period, this volume has been reduced to 95% of historic emissions. From this amount, 15% of allowances has been auctioned and the remaining allowances are allocated to aircrafts operator free-of-charge. Moreover, the special reserve of 3% for new and fast-growing operators has been also created within the second trading period. Allocation of emission allowances free-of-charge to individual operators is determined on the basis of multiplication of a benchmark[12] and the volume of verified tonne-kilometres in 2010.

An aircraft operator included in the EU ETS is obliged to annually monitor and report CO2 emissions produced during the calendar year. Tonne-kilometre data are monitored and reported only for the purposes of applying for free allocation of emission allowances for trading periods or for allocation of free emission allowances from the special reserve.

Each aircraft operator performing flights included in the EU ETS scope is assigned to the administrations of one of the EU Member States as determined by the aircraft operator list which is published annually by the European Commission. The overview of EU ETS coverage in the Czech Republic is included in the Table 4.2 below.

Table 4.2 The EU ETS coverage in the Czech Republic in the period 2012-2020

Year	**# of Aicraft Operators administered**	**CO_2 emissions [tones]**		**Total CO_2 emissions [tones]**
		Domestic flights	**International flights**	
2015	5	12 489	417 940	430 429
2016	5	13 761	464 642	478 404
2017	6	12 830	482 176	495 007
2018	6	12 228	500 602	512 831
2019	6	6 925	477 234	484 159
2020	6	2 276	102 469	104 744
2021	6	3 621	159 893	164 463

Source: MoE

Mitigation impact: The 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. The main assumptions are that the EU ETS directly influences about 41% of final energy consumption in the industrial sector, and indirectly about 75% heat consumers and

[12] The benchmark was determined by the European Commission by Decision No. 2011/638/EU

100% electricity consumers. Having in mind that the State Energy Policy envisages the 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 a drop of GHG emissions caused by energy savings and changes in use of individual energy carriers. Table 4.3 and Table 4.4 show annual emissions savings from realized and planned investments in for free transitional allocations from the year 2015.

Table 4.3 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**

Source: MoE

Table 4.4 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

Source: MoE

The following table summarizes the total effect of the EU ETS.

Table 4.5 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

Source: MoE

Additional information: It is expected that the EU ETS policy together with the Industrial Emissions 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.

Sector: Energy sector (public and industrial), industrial technologies (refineries, chemical sector, metallurgy, coking plants, lime production, cement, glass-making, ceramics, paper and cellulose), aviation

Greenhouse gas coverage: CO_2, N_2O

4.2.3 *Effort Sharing Legislation (Effort Sharing Decision, Effort Sharing Regulation)*

The Effort Sharing legislation establishes annual targets for GHG emissions of the EU Member States between 2013-2020 (by the Effort Sharing Decision, further referred as "Decision" or "ESD"[13]) and 2021-2030 (Effort Sharing Regulation, henceforth "Regulation" or "ESR"[14]) which are legally binding and only refer to GHG emissions that are not included within the scope of the EU ETS, i.e. transport (except aviation), buildings, agriculture (excluding LULUCF) and waste.

Based on the ESD, which was adopted in 2009 and forms part of the EU´s climate and energy policy framework for 2020, the emission limit for the Czech Republic is +9 % by 2020 compared to 2005 levels.

In accordance with Article 14 of the Decision, the European Commission prepared an evaluation of the implementation of the ESD up to 2015. The evaluation concluded that the commitments under the Decision have contributed to stimulating new national policies and measures promoting effective reductions of greenhouse gas emissions. It also found that the Decision has resulted in MS becoming more active in considering new measures to reduce emissions in those sectors within the Decision's scope, as well as in improved coordination between national, regional and local governments.

The results of the evaluation were used by the Commission when preparing the Regulation, legislation setting out binding annual greenhouse gas emission targets for MS for the period 2021-2030. The Regulation was adopted in 2018 and maintains the main elements of the ESD architecture, including the binding annual greenhouse gas emission targets for each Member State. The main changes in the Regulation from the current Decision are as follows:

- Existing flexibilities under the ESD (e.g. banking, borrowing, buying and selling) are retained, and two new flexibilities are added to allow for a fair and cost-efficient achievement of the targets. These are:
    - A one-off flexibility to transfer a limited amount of allowances from the EU ETS: This allows eligible MS to achieve their national targets by covering some emissions in the non-ETS sectors with EU ETS allowances which would normally have been auctioned.
    - A new flexibility to transfer a limited amount of credits from the land use, land use change and forestry sector (LULUCF): To stimulate additional action in the LULUCF sector, the proposal permits MS to use up to 280 million credits over the entire period 2021-2030 from certain land use categories to comply with their national targets.
- Emission limits will be set for each year in the 10-year period up to 2030. The limit for each year is set according to a decreasing linear trajectory. This ensures year on year

[13] Decision No 406/2009/EC - Effort of Member States to reduce their greenhouse gas emissions to meet the Community's greenhouse gas emission reduction commitments up to 2020

[14] Regulation (EU) 2018/842 - Binding annual greenhouse gas emission reductions by Member States from 2021 to 2030 contributing to climate action to meet commitments under the Paris Agreement and amending Regulation (EU) No 525/2013

reductions and adds integrity to the 2030 target because it is the culmination of reductions over 10 years rather than a stand-alone point.

In 2020, the total amount of ESD emissions was 58.65 Mt CO_2 eq.

The EU is on track to overachieve its 2020 target of reducing GHG emissions by 10% compared to 2005 in the sectors covered by the legislation. In relation to ESR**,** by 2030 the national targets will collectively deliver a reduction of 30% compared to 2005 levels. The ESR translates this commitment into binding annual greenhouse gas emission targets for each MS based on the principles of fairness, cost-effectiveness, and environmental integrity. The resulting 2030 targets range from 0% to -40% compared to 2005 levels with the Czech Republic´s emission reduction target being -14 % compared to 2005 levels.

Currently a legislative procedure for the revision of the ESR, a part of the Fit for 55 legislative package, is almost completed. The main change is the increase of the EU level target from 30 to 40%. The respective target for the Czech Republic increased from -14% to -26% compared to 2005 levels.

Type of policy: Regulatory, Economic

Implementing entity: Ministry of the Environment

Period of implementation: ESD 2013-2020, ESR 2021-2030

Implemented in scenario: WEM

Mitigation impact: As the ESD and Regulation are a framework measure, its mitigation impact is accounted under other measures.

Sector: Energy, Transport, Industrial Processes, Agriculture, Waste

Greenhouse gas coverage: CO_2, CH_4, N_2O, HFCs, PFCs, SF_6

4.2.4 Governance of the Energy Union

In 2018, the regulation on the Governance of the Energy Union and Climate Action entered into force.

Agreed as part of the “Clean energy for all Europeans” package, the goals of the new regulation are:

- To implement strategies and measures which ensure that the objectives of the Energy Union, in particular the EU’s 2030 energy and climate targets, and the long-term EU greenhouse gas emissions commitments are consistent with the Paris agreement;
- To stimulate cooperation between EU Member States to achieve the objectives and targets of the Energy Union;
- To promote long-term certainty and predictability for investors across the EU and foster jobs, growth and social cohesion;
- To reduce administrative burdens, in line with the principle of better regulation. This was done by integrating and streamlining most of the current energy and climate

planning and reporting requirements of EU countries as well as the European Commission's monitoring obligations;

- To ensure consistent reporting by the EU and its MS under the UNFCCC and the Paris agreement, replacing the existing monitoring (Regulation (EU) No 525/2013) and reporting system from 2021 onwards.

Further, according to Regulation (EU) 2018/1999 of the European Parliament and Council on Governance of the Energy Union and Climate Action, all MS shall prepare an Integrated National Energy and Climate Plan (NECP). The final version of such plan shall be submitted to the European Commission by the end of 2019. In these plans, the MS have to set out their objectives, targets and contributions relating to the five dimensions of the Energy Union. These dimensions include decarbonisation, energy efficiency, energy security, internal energy market, research, innovation and competitiveness. The first plan will cover the time period 2021-2030. The projections will be prepared until 2040 for all dimensions of the Energy Union. Longer term perspectives in line with the objectives of the Paris Agreement should be included where relevant and possible. According to article 14 of the Regulation NECP should be updated by 30 June 2023 (draft)/30 June 2024 (final version) or else members states should provide the justification, why the update is not required. By 15 March 2023, and every two years thereafter, each Member State shall report to the Commission on the status of implementation of its integrated national energy and climate plan by means of an integrated national energy and climate progress report covering all five dimensions of the Energy Union.

According to the new rules laid out in the Governance regulation, EU countries were also required to develop national long-term strategies by 1 January 2020, and consistency between long-term-strategies and NECPs has to be ensured.

Type of policy: Regulatory

Implementing entity: Ministry of the Environment (Government)

Period of implementation: 2021–2050

Implemented in scenario: WEM

Mitigation impact: As this is a framework measure, its mitigation impacts will be accounted under other measures.

Sector: Cross-sectoral

Greenhouse gas coverage: CO_2, CH_4, N_2O, HFCs, PFCs, SF_6

4.2.5 Act No. 201/2012 Coll., on Air Protection

Current legal framework for the air protection consists of Act No. 201/2012 Coll., on Air Protection, its amendments and implementing regulations and its objective is to prevent air pollution as well as to reduce the level of air pollution to limit health risks, lower the environmental burden of substances discharged into the air and harming ecosystems and setting the conditions allowing the regeneration of the environment affected. The Act transposes a number of EU Directives in the area of air protection (such as Directive 2010/75/EU, 2008/50/ES, 2016/2284 etc.), regulates required ambient air quality and its monitoring obligations of source operators, defines emission limits and other operational conditions for stationary source operators.

In the recent years the Air Protection Act was amended several times, last one was the Act No. 284/2021 Coll., entered into force on January 1st, 2022 and includes changes regarding the adoption of New Building Act – Act No. 283/2021 Coll. This amendment to the Air Protection Law changes the jurisdiction of Air Protection Administrative bodies and legal form of administrative acts regarding evaluation of the potential impact of building projects and their construction on the ambient air quality. Some of the responsibilities, regarding mostly projects with potentially low or none impact on the ambient air quality, which were up until now designated to the Air Protection Administrative bodies have been transferred to the newly engineered State Building Administration bodies.

Type of policy: Regulatory

Implementing entity: Ministry of the Environment (Government)

Period of implementation: Since 2002 (amendments in 2019, 2020, 2021)

Implemented in scenario: WEM

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

Sectors: Energy, Industrial Processes, Agriculture, Waste

Greenhouse gas coverage: CO_2, N_2O, CH_4

4.2.6 Emission Limits in Air Protection Act (201/2012 Coll.)

The Air Protection Act (No. 201/2012 Coll.) further focuses on the transposition of certain parts of the Directive 2010/75/EU on industrial emissions (the Industrial Emissions Directive, henceforth “IED”) amending and subsequently repealing Directives 96/61/EC and 2008/1/EC.

The law provisions of the 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 sets stricter emission limits for selected basic pollutants (in comparison to repealing Directives) and requires the use of the best available techniques (henceforth “BAT”).

The IED aims at minimizing pollution from various industrial sources. The 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 must be based on the use of BAT. The BAT conclusions (documents containing information on the emission levels associated with BAT) serve as references for setting permit conditions.

Certain parts of the IED are implemented into the Czech legislation also by the Act No. 69/2013 Coll. amending the Act No. 76/2002 Coll., on Integrated Prevention and Pollution Control.

Type of policy: Regulatory

Implementing entity: Ministry of the Environment (Government)

Implemented in scenario: WEM

Mitigation impact: The Air Protection Act and the Act on Integrated Prevention and Pollution Control have 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. This is a framework measure and its mitigation effect is accounted in other measures.

Table 4.6 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

Source: CHMI

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 indirectly to switch to cleaner fuels like natural gas or biomass.

Sectors: Energy, Industrial Processes, Agriculture, Waste

Greenhouse gas coverage: CO_2

4.2.7 National Emissions Reduction Programme

The National Emissions Reduction Programme (henceforth "NERP") is the fundamental conceptual material in the area of air quality and reduction of emissions from air pollution sources. It is processed on the basis of Article 8 of the Act No. 201/2012 Coll., on Air Protection, as amended.

The current Programme was approved in December 2019 by the resolution of the Czech Government No. 917. The Programme complies with the requirements set by the Directive (EU) 2016/2284 of the European Parliament and of the Council on the reduction of national emissions of certain atmospheric pollutants for so called national air pollution control programmes (Article 6 of the Directive).

It comprises of analyses of the state of air and its development in the Czech Republic, causes of air pollution, emissions of pollutants from particular sectors of national economy, air pollution scenarios, international commitments of the Czech Republic as well as their fulfilment.

The NERP defines a set of goals together with procedures and measures to achieve these goals including terms of their attainment and the assignment of responsible authorities for the measures´ implementation.

The main objective of the NERP is to meet the national emission reduction commitments applicable from 2020 to 2029 and from 2030 onwards, as laid down by the Directive.

For the implementation of the Programme a set of 6 priority measures, 14 subsidiary measures and 7 cross-sectional measures has been introduced at the national level directly aimed to reduce emissions and to improve air quality. These measures are assigned to each central authority of the state administration to be accomplished and are described in detail on cards of measures. For the priority measures the effect of their implementation on the emission reduction was quantified.

The measures are to be implemented in the public energy sector and household heating sector, in the transport sector and agriculture sector, predominantly in the form of legislative changes and economic instruments.

Following the requirements of the Directive 2016/2284 the implementation of the measures set by the NERP and achievement of its' goals is evaluated regularly and an update of the NERP will be prepared in 2023.

Type of policy: Regulatory

Implementing entity: Ministry of Environment (Government)

Implemented in scenario: WEM

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

Sector: Energy; Industrial processes and product use; Transport, Agriculture**,**

Greenhouse gas coverage: CH_4, N_2O, CO_2

4.3 Sectoral Policies and Measures

4.3.1 Energy Sector

Policies and Strategies

a) State Energy Policy

The State Energy Policy (henceforth "SEP") is the main strategic document for the energy sector in the Czech Republic. The Policy is cross-sectional as it serves as the framework strategic document for the national level.

The new SEP was approved by the Government in May 2015 and replaced the previous SEP from the year 2004. The SEP is codified in Act No. 406/2000 Coll., on Energy Management. A time horizon of SEP is 25 years, with expected evaluation at least every five years and annual assessments of implementation measures. According to the aforementioned legislation, the SEP is binding for the government and state institutions and sets targets by the year 2040.

The main purpose of the SEP is to ensure reliable, secure and environmentally-friendly supply of energy to meet the needs of the population and economy of the Czech Republic, at competitive and acceptable prices under standard conditions. It must also secure uninterrupted energy supply in crisis situations to the extent necessary to ensure the functioning of the main components of the state and the survival of the population.

The SEP (2015) has three strategic objectives – the security of energy supply, competitiveness, and sustainability. These three strategic objectives are further translated into more concrete strategic priorities of the energy sector in the Czech Republic, namely i) balanced energy mix;

ii) savings and efficiency; iii) infrastructure and international cooperation; iv) research, development and innovation; and v) energy security.

The indicative targets are set by the SEP for the year 2040 and are expressed in terms of corridors that ensure a balanced mix of sources for electricity generation and corridors for the composition of a diversified mix of primary energy sources. The use of domestic primary sources is prioritised (desired level of 80% of domestic sources in gross electricity production) as well as keeping import dependence at an acceptable level.

Target structure of electricity generation for the year 2040 is as follows:

Nuclear fuel	46-58%
Renewable and secondary sources	18-25%
Natural gas	5-15%
Brown and black coal	11-21%

Target structure of primary energy sources (for the year 2040):

Nuclear fuel	25-33%
Solid fuels	11-17%
Gas fuels	18-25%
Liquid fuels	14-17%
Renewable and secondary sources	17-22%

The SEP also includes other indicative indicators and targets. These should ensure the tracking of the progress and enable assessment of possible needs for SEP updates. The SEP has also a dedicated section for implementation instruments, those are mainly: i) legislative instruments; ii) instruments in the area of state administration; iii) fiscal and tax instruments; iv) foreign policy instruments; v) instruments in education and support for science and research; vi) exercise state ownership rights in energy companies in which the Czech Republic has an ownership interest; and vii) communication and media promotion. There was also annual monitoring of the progress of fulfilment of implementation instrument through dedicated reports (link).

According to Act No. 406/2000 Coll. the SEP should be assessed by maximum five years from its approval. The Assessment of SEP was prepared in 2020 (link) and approved by the government on 8th of March 2021 (by the government resolution No. 260). Based on this Assessment government approved the update of the SEP. The update of the SEP should be prepared by the end of 2023 and should reflect recommendations provided in the Assessment in particular, to extend the horizon of the Concept until 2050 and to further consider the commitments made, in particular at European Union level, the conclusions of the Coal Commission and the trend in the development of modern technologies.

Type of Policy: Regulatory

Implementing entity: Ministry of Industry and Trade (Government)

Period of implementation: 2015-2040

Implemented in scenario: WEM

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

Sectors: Energy, Transport, Industrial Processes (in general all combustion processes)

Greenhouse gas coverage: CO_2

b) National Renewable Energy Action Plan (NREAP)

The Plan implements the Renewable Energy Directive 2009/28 (henceforth "RED Directive") which requires the EU Member States to cover a specified percentage of final energy demand by renewable energy in 2020. The Czech Republic is committed to achieve 13% share of RES in 2020, while the total EU target is 20%.

The main aim of the RED Directive is to establish a common framework for the promotion of energy from renewable energy sources and its principal requirements include the following points:

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

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

The NREAP is evaluated every two years by the Ministry of Industry and Trade. The results are reported to the Government and the European Commission.

The NREAP was replaced by the appropriate documents within the governance framework (based on EU Regulation 2018/1999), namely NECP and relevant integrated reports. Contribution of CZ to the RES target on the EU level was set on the level of 22 % of RES share on the gross final energy consumption (EUROSTAT methodology) by 2030.

Type of Policy: Economic, Fiscal

Implementing entity: Ministry of Industry and Trade (Government)

Period of implementation: 2010-2020

Implemented in scenario: WEM

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

Table 4.7 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

Source: European Commission

Table 4.8 Share of RES in final consumption of energy according to NREAP (2015) and draft National Energy and Climate Plan based also on revised methodology for 2005 data (NECP, 2019)

	2005 (NREAP)	2020 (NREAP)	2005 (NECP)	2020 (NECP)
RES consumption [PJ]	76.2	172.9	82.5	182.8
The share of RES [%]	6.1	15.3	7.09	16.3

Source: MoE, MIT

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

Sectors: Energy

Greenhouse gas coverage: CO_2, CH_4

c) National Energy Efficiency Action Plan (NEEAP)

The National Energy Efficiency Action Plan (henceforth "NEEAP") sets the national target for energy savings and describes existing and planned measures to reach this target. It implements the Directive 2012/27/EU that 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;
- Energy consumers should be empowered to better manage 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.

The 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. The latest update of the NEEAP from 2017 sets the target for the Czech Republic at 51.10 PJ of new final energy savings by 2020. The slight increase of the target follows the revision of energy statistics by Eurostat.

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.

Tab. 4.9 Calculation of the binding savings target stipulated in the Directive, Article 7(2)

Year	**2017**	**2018**	**2019**	**2020**
Savings [PJ]	38.93	48.66	58.40	68.13

Source: MIT

The NEEAP was replaced by the appropriate documents within the governance framework (based on EU Regulation 2018/1999), namely NECP and relevant integrated reports. Contribution of CZ to the EU EE target (Art. 3 of the Energy Efficiency Directive) is to not exceed the level of 990 PJ of final energy consumption by 2030. Furthermore, there are national obligations under art. 7 of the Energy Efficiency Directive set on the level of 462 PJ of cumulative final energy savings by 2030 and continuation with the 3 % renovation of the total floor area of heated and/or cooled buildings owned and occupied by its central government bodies each year under art. 5 of the Energy Efficiency Directive.

Type of policy: Economic, Fiscal, Information, Voluntary

Implementing entity: Ministry of Industry and Trade (Government)

Period of implementation: 2008-2020

Implemented in scenario: WEM

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

Sectors: Energy, Transport, Industrial Processes (in general all combustion processes)

Greenhouse gas coverage: CO_2

Legislative Instruments

a) Act No. 406/2000 Coll., on energy management

This Act transposes relevant EU legislation including Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and subsequently repealing Directives 2001/77/EC and 2003/30/EC, Directive 2009/125/EC of the European Parliament and of the Council of 21 October 2009 establishing a framework for the setting of ecodesign requirements for energy-related products, Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings and Directive 2012/27/EU of the European Parliament and the Council of 25 October 2012 on energy efficiency.

The Act stipulates requirements for efficiency of energy use (construction and reconstruction of the electricity generation plant, heat generation plant and combined heat and power generation plants, inspections of boilers and hot water supply, including the internal distribution of thermal energy in buildings and inspection of air conditioning systems). The Act further sets the minimum energy performance standard for new buildings on the level of nearly-zero energy standard and for major renovations and building parts changes on the cost optimum level. It further introduces energy performance certificates in case of construction, major renovation, sales and rentals of buildings or its parts. It also includes energy performance requirements for electrical appliances and introduces their certificates. Building owner, association of unit owners or building manager is obliged to arrange regular inspections of the heating and air-conditioning system with an effective rated output above 70 kW.

The Act requires large enterprises with energy consumption of their energy facilities more than 200 MWh per year to perform an energy audit. The obligation does not apply to enterprises that have the standard EN ISO 50001 established and certified. The SME are obliged to perform an energy audit if the energy consumption of their energy facilities is more than 5 000 MWh per year. The requirement to perform an energy audit also applies to government institutions, regions, municipalities and certain public organizations that have energy consumption of their energy facilities greater than 200 MWh per year.

The act sets professional requirements for energy specialists who process the energy audits, energy assessments, issue energy performance certificates and perform controls of heating and air-conditioning systems. In line with the Act energy specialists must undergo a regular training in 3 year cycles prepared by the State energy Inspection that is also a control body for obligations defined within the Energy Management Act.

The act introduces an obligation for an electricity or thermal energy producer, in newly established installations, to provide for at least the minimum efficiency of energy use stipulated by an implementing legal regulation. This obligation also applies to installations for production of electricity or thermal energy in which a change is introduced in previously completed structures. Owners are obliged to regularly perform checks of operating boilers, and heat distribution and air conditioning systems.

The Act requires manufacturers or authorized representatives that their products comply with the eco-design requirements when placed on the market or put into the service. The specific requirements for each product group are set in the Commission regulations in order to encourage manufacturers to design products in an environmentally friendly way with the lowest possible negative environmental impact.

Type of policy: Regulatory

Implementing entity: Ministry of Industry and Trade (Government)

Period of implementation: Since 2000

Implemented in scenario: WEM

Mitigation impact: This is a framework measure and its mitigation effect is accounted in other measures. For instance, in relation to the application of eco-design, the annual energy savings were calculated in the NEEAP III of the amount of 1230 TJ/year by 2020.

Sectors: Energy

Greenhouse gas coverage: CO_2

b) Directive 2012/27/EU on energy efficiency (Article 5, Article 7)

According to the Article 5 of the Directive, 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.

According to the Article 7 of the Directive, the MS should annually achieve or secure specific amount of cumulative energy savings (in PJ) on final energy consumption side through specific measures introduced by government or private entities or mix of both. The Czech Republic has decided to achieve its 204,4 PJ cumulative energy savings obligation by 2020 via so-called "alternative scheme" which counts the energy savings achieved thanks to individual governmental sub-programmes which are focused on support of households, municipalities and companies´ energy saving projects.

On 14th of July 2021 European commission published legislative package "Fit for 55", which also included proposal of the amendment of Energy Efficiency Directive.

Type of policy: Regulatory

Implementing entity: Ministry of Industry and Trade (Government)

Period of implementation: 2012-2030

Implemented in scenario: WEM

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

Sectors: Energy

Greenhouse gas coverage: CO_2

c) Directive 2010/31/EU on the energy performance of buildings

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 heating and air conditioning and ventilation systems in buildings with an effective rated output greater than 70 kW.

The Directive is transposed by the Act No. 3/2020 Coll., on energy management. The directive defines new administrative tools to reduce energy consumption of buildings. It defines a building with nearly 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 renewable sources of energy (henceforth “RES”).

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

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

Since 31st December 2020 , all new buildings shall be buildings with nearly zero energy consumption. From 2019 all new buildings used or owned by public administration shall be buildings with nearly zero energy consumption. According to the Directive “a building with nearly zero energy consumption” is a building with very low energy consumption. 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 consumption taking into account cost optimization. Contact to other information sources, especially regarding cost efficiency shall be included in the certificate as well.

The directive introduces requirements for electromobility or ducting infrastructure for residential and non-residential buildings. Furthermore, by 1 January 2025, it stipulates the obligation to install a minimum number of charging stations in all non-residential buildings with more than twenty parking spaces.

The directive requires Member States to establish a long-term renovation strategy to support the renovation of the national stock of residential and non-residential buildings, both public and private, into a highly energy efficient and decarbonized building stock by 2050, facilitating the cost-effective transformation of existing buildings into nearly zero-energy buildings.

Also, an optional common Union scheme for rating the smart readiness of buildings was prepared from the European Commission.

On 15th of December 2021 European commission published part of legislative package “Fit for 55”, which also included proposal of the amendment of Energy Performance of Buildings Directive.

Type of policy: Regulatory

Implementing entity: Ministry of Industry and Trade (Government)

Period of implementation: Since 2010

Implemented in scenario: WEM

Mitigation impact: Emission reduction effects are shown in Table 4.10 below.

Table 4.10 Emissions reduction expected from implementation of Directive 2010/31/EU

Emissions reduction [kt CO_2 eq.]	2020	2025	2030	2035	2040
	532	474	446	446	446

Source: CHMI

Sectors: Energy

Greenhouse gas coverage: CO_2

d) Directive 2009/125/ES on eco-design

Eco-design is a method for the design and development of products, 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 eco-design directives have been implemented into the Czech legislation by the Energy Management Act No. 406/2000 Coll. and by its amendments 393/2007 Coll. and 53/2012 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, servers and data storage products;
- Domestic cooking appliances;
- Electric motors;
- Electronic displays;
- 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;
- Refrigerating appliances with a direct sales function;
- Refrigerators and freezers;
- Simple set-top boxes;
- Standby and off mode electric power consumption of household and office equipment, and network standby;
- Vacuum cleaners;
- Ventilation units;
- Water pumps
- Welding equipment.

Type of policy: Regulatory

Implementing entity: Ministry of Industry and Trade (Government)

Period of implementation: Since 2009

Implemented in scenario: WEM

Mitigation impact: Application of the eco-design leads to electricity savings. The annual energy savings were calculated in the NEEAP III of the amount of 1230 TJ/year by 2020. The expected emissions reduction effects are shown in the Table 4.11 below.

Table 4.11 Emissions reduction expected from implementation of Directive 2009/125/ES on eco-design

	2020	**2025**	**2030**	**2035**	**2040**
Emissions reduction [kt CO_2 eq.]	438	484	466	363	363

Source: CHMI

Sectors: Energy

Greenhouse gas coverage: CO_2

e) Act No. 165/2012 Coll., on supported sources of energy

This Act was amended by Act No. 310/2013 Coll., on support of energy sources (SES Act), as amended by Act No. 407/2012 Coll., and other laws. The amendment has cancelled the support provided to some types of new electricity generating facilities from renewable sources since 2014, with one-year transition, allowing completion of projects in progress. It also defines the maximum fee levied for the support of renewable sources, which will be collected from customers within the regulated price of electricity and introduces levy on electricity generated from solar radiation effective as of January 1st, 2014 for facilities put into operation in 2010.

The Act transposes Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC.

This Act regulates:

a) Support provided to generation of electricity, heat and bio-methane from RES, secondary energy sources ("secondary source"), highly efficient combined production of electricity and heat and decentralized electricity generation, exercise of state administration and related rights and obligations of persons involved,

b) Content and creation of the National Action Plan of the Czech Republic for energy from RES ("National Action Plan"),

c) Conditions for issue, record-keeping and acknowledging guarantees of energy originating from RES,

d) Conditions for certification on origins of electricity generated from highly efficient combined production of electricity and heat or from secondary sources,

e) Financing of the support of electricity generated from supported sources, heat from RES, decentralized electricity production, bio-methane and provision of subsidy to market operator to cover these expenses,

f) Levies on electricity generated from solar radiation,

g) Increase of the share of RES on consumption of primary energy sources,

h) Creation of conditions for the fulfilment of binding share of energy from RES on the gross final consumption of energy in the Czech Republic while simultaneously reflecting interests of the customers on minimising the impacts on energy prices in the Czech Republic.

The main purpose of this amendment to the SES Act was to introduce measures aimed to stabilize the impact of support for energy from RES on the Czech industry competitiveness and on the citizen's energy bills of the Czech Republic due to the increasing financial burden of this support.

Key changes to the SES Act included namely:

- Suspension of support for electricity from RES (excluding hydropower plants with an installed capacity of up to 10 MW) generated in plants commissioned after 31 December 2013;
- Suspension of support for production of bio-methane after 31 December 2013 (due to the length of time required to finish installations under construction;
- Support for wind power plants (with valid building permit as of 1 October 2013) commissioned by 31 December 2014 and hydropower plants with an installed capacity of over 10 MW commissioned by 31 December 2015 shall be maintained);
- Continued support for secondary sources, in particular waste for incinerators;
- Cessation of support for decentralized production;
- Continuation of solar levy for installations commissioned in the year 2010;
- Fixing the contribution to the supported RES in cost of electricity for end consumers.
- Separation of the price component for support of RES and other supported sources from the prices for electricity transmission and distribution and its inclusion in a special price to cover costs associated with support for electricity and heat and setting a ceiling for this price at CZK 495/MWh;
- Change in the solar levy on electricity generated after January 1st, 2013.
- As of 31 July 2014, aid recipients will be required to disclose their owners (in response to passing of Act No. 134/2013 Coll., on Certain Measures to Improve Transparency of Joint Stock Companies and on Amendments to Other Laws).

Act on supported sources of energy was further amended by the Act No. 382/2021 Coll. This amendment is the most extensive amendment since the approval of the original Act in 2012. It also to a large extend implements Renewable energy directive). This amendment modifies or add a number of definitions, introduce new overall framework for the support of supported sources (most notably it introduces framework for the auctioning scheme for operational support), introduces new framework of support for the development of RES specifically in the transport sector (namely for biomethane production), revisions the rules for the sustainability criteria, modifies rules with regard to guarantees of origins etc. Following this amendment process there is on-going update and preparation of new secondary legislation.

Type of policy: Regulatory

Implementing entity: Ministry of Industry and Trade (Government)

Period of implementation: Since 2013

Implemented in scenario: WEM

Mitigation impact: This policy is a framework measure and thus its mitigation effect is accounted under other measures

Sectors: Energy

Greenhouse gas coverage: CO_2, CH_4

f) Directive 2009/28/ES on the promotion of the use of energy from renewable sources (Preferential feed-in tariffs for electricity produced from renewable energy sources)

The Directive 2009/28/ES on the promotion of the use of energy from renewable sources was replaced by the Renewable Energy Directive, Directive (EU) 2018/2001. The directive 2018/2001 was to a large extend implemented by Act 382/2021 Coll. on promoted sources of energy, which is the amendment of Act 165/2012 Coll. On 14th of July 2021 European commission published legislative package “Fit for 55”, which also included proposal of the amendment of Renewable Energy Directive.

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.

According to National Renewable Energy Action Plan 2020 the target of 15.3% share of renewable energy in electricity production will be met.

Type of policy: Economic

Implementing entity: Energy Regulatory Authority (Government)

Period of implementation: Since 2009

Implemented in scenario: WEM

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.

Table 4.12 Emissions reduction expected from introduction of preferential feed-in tariffs for electricity produced from RES

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

Source: CHMI

Sectors: Energy

Greenhouse gas coverage: CO_2

g) Act No. 458/2000 Coll., on business conditions and public administration in the energy sectors (Energy Act)

The Act transposes relevant EU legislation[15], includes directly applicable EU legislation[16] and sets conditions for business, for public administration and for energy regulation (electricity, gas and heat) while also regulating rights and obligations of natural persons and legal entities. It concerns organization of business activities in the energy sector while maintaining economic competition, meeting the needs of consumers, rights of license holders and ensuring safe, secure and stable supply of electricity, gas and heating at acceptable prices.

The amendment of the Act No. 131/2015 Coll. removed some administrative barriers for small photovoltaic installations (up to 10 kW), which are no longer subject to licensing and introduced support for heat from biomass installations. The last amendment was through the Act 362/2021 Coll., which focused specifically on the strengthening of the consumer protection.

The preparation of new Energy Act is under preparation. In October 2019 the government considered thesis (principal approach) of the Act. In December 2020 the government approved substantive intent of the new Act. The new legislation introduces an active customer, a new entity in the form of an energy community, new activities in the electricity market such as aggregation, energy storage and the provision of flexibility. The resulting law should thus be in line with energy sector developments such as decentralisation of generation, greater involvement of renewable energy sources, electricity consumption management, increasing energy efficiency, energy storage and sector coupling. Considering the length of legislative process, the new Energy Act is expected to come into force in 2024 at the earliest.

Type of policy: Regulatory

Implementing entity: Ministry of Industry and Trade (Government)

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[15] 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

[16] 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.

Period of implementation: Since 2000

Implemented in scenario: WEM

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

Sector: Energy

Greenhouse gas coverage: CO_2

<u>Financial Schemes and Programmes</u>

a) State Program to Support Energy Savings and Use of Renewable Energy Sources (EFEKT)

The EFEKT is a national plan developed to promote measures to increase energy efficiency and to incentivize the use of renewable and secondary energy sources in accordance with the approved State Energy Policy and sustainable development principles. Specifically, it supports energy information distribution, awareness raising activities, organization of public seminars, energy information centers and small investment actions leading to energy savings and the 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 NGOs.

The State Programme to Promote Energy Savings and the Use of Renewable Sources of Energy was adopted by Government Resolution No. 1105/2004. Its scope and funding is defined in Act No. 406/2000 Coll., on energy management (as amended by Act No. 61/2009 Coll.).

This programme represents the implementation tool for the State Energy Policy and Czech commitments toward the EU in the area of energy efficiency. It is supplemental programme to energy programmes financed from the EU Structural Funds.

The State Programme to Promote Energy Savings and the Use of Renewable Sources of Energy focuses on reducing energy consumption, use of renewable and secondary energy sources in line with economic and social needs, sustainable development and protection of the environment. Besides that it focuses on education, energy planning, small-scale investment actions and pilot projects. The most significant emission reductions have been achieved in the energy sector, protection of the environment area, renewable sources energy (RES) and energy savings in industry and in housing sector.

The Programme has been implemented during its initial run (since 2005) not only by the Ministry of Industry and Trade (which coordinates the entire programme), but also by ten other ministries. Since 2007, the programme has been renamed to Programme EFEKT, and as such it has been fully implemented only by MIT. The Programme EFEKT has provided support for various projects during the 2007-2013 period.

In 2016, the programme has been amended for the 2017-2021 period and is now called *State programme to promote energy savings*. The yearly budget has been increased to CZK 150 mil. The new so called EFEKT 2 is particularly aimed at soft measures such as promoting education and raising awareness in the area of energy savings, but also at smaller scale investment actions and pilot projects. The new programme does not support the use of renewable energy anymore and focuses solely on energy efficiency measures. One of the most important supported areas of the programme is increasing energy efficiency in public lighting systems.

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 is implemented only by the Ministry of Industry and Trade

Implemented in scenario: WEM

Mitigation impact: The expected energy savings of the Programme EFEKT are shown in the table below.

Table 4.13 Expected energy savings of programme EFEKT

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

Source: CHMI

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.

Table 4.14 Expected emissions reduction of programme EFEKT

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

Source: CHMI

Only new effects after 2015 are included in the tables.

The energy savings in 2020 are expected to be 298 TJ. The budget of the program is estimated to be CZK 0.1 bill. The programme undergoes annual evaluation to update contents and budgets of the individual parts of the programme.

Sector: Energy

Greenhouse gas coverage: CO_2

b) State Programme on the Promotion of Energy Savings (EFEKT 2 and EFEKT 3)

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 NGOs. This programme also supports the following activities: measures to reduce energy intensity of public street lighting; heating system reconstruction and heat generation in buildings; publications, guides and informative materials about the energy sector; introduction of an energy management system; preparation of energy-saving projects financed using the Energy Performance Contracting method. The budget of the program is estimated to be CZK 0.7 bill. for the period 2017-2020. The program contributes to reach the energy target according to Directive 2012/27/EU on energy efficiency.

In 2020, the programme has been amended for the 2022-2027 period and is now called *State programme to promote energy savings*. The yearly budget has been increased to CZK 160 mil. The new so called EFEKT 3 is particularly aimed at soft measures such as promoting education and raising awareness in the area of energy savings. The new programme does not support the use of renewable energy anymore and focuses solely on energy efficiency measures. One of the most important supported areas of the programme are pre-project preparation subsidies, education programmes and consulting services for public "EKIS". The renewed programme is expected to save in the period to 2030 17,8 PJ.

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

Implementing entity: Ministry of Industry and Trade (Government)

Period of implementation: Since 2017 and renewed from 2022

Implemented in scenario: WEM

Mitigation impact: The expected programme energy savings are shown in the following table.

Table 4.15 Expected energy savings of programme EFEKT 2 and EFEKT 3

	2020	**2025**	**2030**	**2035**	**2040**
Energy savings [TJ]	778	778	778	778	778

Source: CHMI

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. 4-16 Expected emissions reduction of programme EFEKT 2 and EFEKT 3

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

Source: CHMI

Sectors: Energy

Greenhouse gas coverage: CO_2

c) New GREEN SAVINGS Programme 2013

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

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.

Type of policy: Economic

Implementing entity: State Environmental Fund (Government)

Period of implementation: In 2013 only

Implemented in scenario: WEM

Mitigation impact: The expected programme energy savings are shown in the following table.

Table 4.17 Expected energy savings of the New Green Savings Programme 2013

Energy savings [TJ]	**2020**	**2025**	**2030**	**2035**	**2040**
	103	103	103	103	103

Source: CHMI

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. 4.18 Expected emissions reduction related to energy savings of the New Green Savings Programme 2013

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

Source: CHMI

Sector: Energy, Residential

Greenhouse gas coverage: CO_2

d) New Green Savings Programme

This programme is a follow-up of previously implemented Green Savings Program and New Green Savings Program 2013. It is implemented by the State Environmental Fund of the Czech Republic and it aims at the improvement of energy performance of single- and multi-family buildings (insulation, 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:

- Construction of family houses and apartment buildings in so-called passive standard (passive houses)
- Purchase of houses and flats with very low energy consumption
- Solar thermal and photovoltaic systems
- Replacement of non-environmental heat sources with heat pumps, boilers or local biomass sources, gas boilers

- Storage tanks for rainwater retention, wastewater recovery
- Green roofs, outdoor shading technology
- Use of heat from waste water
- Controlled ventilation systems with heat recovery (recuperation)
- Purchase and installation of charging stations for electric vehicles
- Planting of trees on publicly accessible land near residential buildings

Depending on the real energy savings, the support it up to 50% of the total eligible expenses (up to 60% if combined with boiler subsidies for lower income households).

During the programming period in 2014-2021, it contributed a total of 16 billion CZK to more than 74,000 beneficiaries. In 2021, the program moves on to the next stage and expands its focus to new areas. In the programming period 2021-2030, it will be financed in the first years from the Recovery and Resilience Facility (RRF) in the National Recovery Plan (total CZK 19 billion). From 2026 onwards the programme should be financed again from the share of revenues from auctioning of EU ETS emission allowances (about CZK 4 billion per year).

Type of policy: Economic

Implementing entity: State Environmental Fund (Government)

Period of implementation: 2014-2030

Implemented in scenario: WEM

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

Table 4.19 Expected energy savings of the New Green Savings Programme 2014–2020

Energy savings [TJ]	**2020**	**2025**	**2030**	**2035**	**2040**
	9 074	9 074	9 074	9 074	9 074

Source: CHMI

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.

Table 4.20 Expected emissions reduction related to energy savings of the New Green Savings Programme 2014–2020

Emissions reduction [kt CO_2 eq.]	**2020**	**2025**	**2030**	**2035**	**2040**
	529.50	467.67	437.83	404.26	364.01

Source: CHMI

Sector: Energy, Residential

Greenhouse gas coverage: CO_2

e) Programme PANEL / NEW PANEL / PANEL 2013 +

The Programme PANEL (NEW PANEL since 2009, PANEL 2013 + since 2013) supports complex renovation and upgrades of residential houses improving their value, lowering their energy intensity and fundamentally extending their lifetime. The program is managed by the State Investment Promotion Fund.

The Programme was established in 2001 by the Government Resolution No. 299/2001 Coll. According to the Resolution, support may be provided to:

- Natural persons or legal entities owning or co-owning a building;
- Natural persons or legal entities owning or co-owning flats or non-residential premises in a building;
- Flat-owners' associations.

Support was provided for specific types of measures or upgrades in panel houses using standardized construction systems. This support was later extended to all residential houses regardless of their construction system.

Projects supported include e.g.:

- Insulation of the building
- Replacement of old external doors and windows 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

Support was provided in the form of:

- Guarantee for loan provided,
- Subsidy toward partial interest from loans.

Since 2013, this programme has been implemented pursuant to Government Resolution No. 468/2012. The support takes the form of a low-interest loan in the programme PANEL 2013 +.

The Ministry of Industry and Trade evaluation of the State Programme to Promote Energy Savings and the Use of Renewable Sources of Energy in 2016 demonstrated that energy savings in all so far renovated apartments receiving PANEL or New Panel support amounted to approximately 5 852 304 GJ.

The expected annual budget for the period 2021–2026 is estimated to be about CZK 270 m.

Type of policy: Economic

Implementing entity: State Housing Fund (Government)

Period of implementation: Since 2001, temporarily suspended in 2010, continues from 2013 and includes annual evaluation and budgeting exercise

Implemented in scenario: WEM

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

Table 4.21 Expected energy savings of the PANEL programme

	2020	2025	2030	2035	2040
Energy savings [TJ]	204	204	204	204	204

Source: CHMI

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.

Table 4.22 Expected emissions reduction related to energy savings of the PANEL programme

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

Source: CHMI

Sectors: Energy, Residential

Greenhouse gas coverage: CO_2

f) Operational Programme Environment 2007–2013

The Operational Programme Environment 2007–2013 was focused on improving the quality of the environment in the Czech Republic. 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 2007–2013 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.

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

Type of policy: Economic

Implementing entity: State Environmental Fund (Government)

Timeframe: 2007-2013

Implemented in scenario: WEM

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

Table 4.23 Energy savings of Operational Programme Environment 2007–2013

Energy savings [TJ]	**2020**	**2025**	**2030**	**2035**	**2040**
	824	824	824	824	824

Source: CHMI

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.

Table 4.24 Emissions reduction related to energy savings of Operational Programme Environment 2007–2013

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

Source: CHMI

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.

Table 4.25 Energy production from RES and reached emissions reduction of Operational Programme Environment 2007–2013

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

Source: CHMI

Sectors: Energy

Greenhouse gas coverage: CO_2

g) Operational Programme Environment 2014–2020

The aim of the Operational Programme Environment 2014–2020 is to protect and improve the quality of the environment in line with the principles of sustainable development in the Czech Republic. Two priority axis relevant to GHG emission reductions are priority axis 2 - Improvement of Air Quality and priority axis 5 – Energy Savings. For the programming period 2014–2020 the total allocation is more than EUR 3 billion including about EUR 1 billion for activities improving air quality and energy efficiency. The priority axis 2 supports mainly the replacement of boilers burning solid fuels with more efficient low-emission boilers combusting biomass, liquid or gas fuels, and heat pumps. The priority axis 5 supports insulation and other energy efficiency measures in public sector and promotes increased use of renewable energy sources. 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). The expected program budget for energy savings and RES support is CZK 23.6 bill. (approx. EUR 907.7 mill.).

Type of policy: Economic

Implementing entity: Ministry of the Environment (Government)

Period of implementation: 2014–2020, all supported projects must be implemented by the end of 2023 at the latest.

Implemented in scenario: WEM

Mitigation impact: It is estimated that by 2023 the energy savings from Priority axis 2 should reach about 3 PJ and energy savings from Priority axis 5 about 2 PJ. The corresponding estimated reductions of GHG emissions are 320 kt CO_2eq for Priority axis 2 and about 300 kt CO_2eq for Priority axis 5.

The expected programme energy savings shows the following table.

Table 4.26 Energy savings of Operational Programme Environment 2014–2020

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

Notice: The 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.

Source: CHMI

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.

Table 4.27 Emissions reduction related to energy savings of Operational Programme Environment 2014–2020

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

Source: CHMI

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:

Table 4.28 Energy production from RES and reached emissions reduction of Operational Programme Environment 2014–2020

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

Source: CHMI

Sectors: Energy

Greenhouse gas coverage: CO_2

h) Integrated Regional Operational Programme (IROP)

The Integrated Regional Operational Programme (IROP) is divided into the following priority axis:

- 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 as well as its objective 2.5 "Reduction of energy consumption in the residential sector".

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 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.

Financial allocation of the specific objective 2.5 is EUR 622 796 485 (approximately CZK 17 billion).

Type of policy: Economic

Implementing entity: Ministry of Regional Development (Government)

Period of implementation: 2014-2020

Implemented in scenario: WEM

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

Table 4.29 Expected energy savings of the Integrated Regional Operating Programme

	2020	**2025**	**2030**	**2035**	**2040**
Energy savings [TJ]	2,561	3,168	3,168	3,168	3,168

Source: CHMI

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. 4-30 Expected emissions reduction related to energy savings of the Integrated Regional Operating Programme

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

Source: CHMI

The expected annual budget for the period 2014-2020 is estimated to be about CZK 13.2 bill. (EUR 507.7 mill.).

Sectors: Energy

Greenhouse gas coverage: CO_2

i) Operational Programme Prague – Growth Pole of the Czech Republic

The operational programme under the auspices of the City of Prague focuses on improving the energy performance of buildings and the technical equipment used to ensure the operation of municipal public and road transport, and the implementation of pilot projects to convert energy intensive municipal buildings into nearly-zero energy buildings. These measures fall within the priority axis 2: Sustainable mobility and energy savings. The expected annual budget for the period 2014-2020 is estimated to be about CZK 1.9 bill. (EUR 74.5 mill.)

Type of policy: Economic

Implementing entity: City of Prague

Period of implementation: 2014-2020

Implemented in scenario: WEM

Mitigation impact:

Table 4.31 Expected energy savings of the Operational Programme Prague Growth Pole

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

Source: CHMI

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.

Table 4.33 Expected emissions reduction related to energy savings of the Operational Programme Prague Growth Pole

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

Source: CHMI

Sectors: Energy

Greenhouse gas coverage: CO_2

j) JESSICA Programme

The programme offers long-term low-interest loans for reconstruction or modernization of residential buildings. It is implemented by the Ministry of Regional Development. 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.
- The expected annual budget for the period 2014-2020 is estimated to be about CZK 0.6 bill. (USD 23.1 mill.).

Type of policy: Economic

Implementing entity: Ministry of Regional Development (Government)

Period of implementation: 2014-2016

Implemented in scenario: WEM

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

Table 4.33 Expected energy savings of the JESSICA programme

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

Source: CHMI

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.

Table 4. 34 Expected emissions reduction related to energy savings of the JESSICA programme

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

Source: CHMI

Sectors: Energy

Greenhouse gas coverage: CO_2

k) ENERG Programme

The programme of the Ministry of Industry and Trade is focused on the provision of soft and interest-free loans for the implementation of projects improving energy performance in the business sector. The administrator of the financial instrument is the National Development Bank.

The budget for the programme was set to almost 130 mil CZK.

Type of policy: Economic

Implementing entity: Ministry of Industry and Trade (Government)

Period of implementation: Since 2017

Implemented in scenario: WEM

Mitigation impact: The expected programme energy savings are shown in the following table.

Table 4.35 Expected energy savings of the ENERG Programme

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

Source: CHMI

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.

Table 4.36 Expected emissions reduction related to energy savings of the ENERG programme

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

Source: CHMI

Sectors: Energy

Greenhouse gas coverage: CO_2

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

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) out of which priority axis 3 (Effective Energy or Eco-Energy) focused on energy savings and on the use of RES (renewable energy sources), thus aiming at GHG reduction. The program aimed at reducing energy intensity in production processes, reducing fossil fuel consumption and at increasing the use of renewable and secondary energy sources. The aid beneficiaries were not only small- or medium-sized, but also large enterprises.

The support also focused on the construction 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 the modernization of existing energy production facilities to increase their efficiency and for implementation of systems measuring and regulating energy. Further, modernization and loss reduction in the transmission of electricity to 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. 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 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.

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

Type of policy: Economic (subsidies)

Implementing entity: Ministry of Industry and Trade (Government)

Period of implementation: 2007-2013

Implemented in scenario: WEM

Mitigation impact: The expected programme energy savings are shown in the following table.

Table 4.37 Energy savings of the OPEI programme

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

Source: CHMI

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.

Table 4.38 Emissions reduction resulting from energy savings of the OPEI programme

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

Source: CHMI

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.

Table 4.39 Energy production from RES and corresponding emissions reduction of the OPEI programme

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

Source: CHMI

Sectors: Energy, Manufacturing industries and construction, Agriculture

Greenhouse gas coverage: CO_2, CH_4, N_2O

m) Operational Programme Enterprise and Innovation for Competitiveness (2014–2020)

The Operational Programme Enterprise and Innovations for Competitiveness (OP EIC) is focused on increasing the competitiveness of the Czech economy by supporting the business environment, promoting innovations in the production and services sectors, energy treatment and the development of ICT. EU funding allocation reached EUR 4.33 billion. Direct impact on effective energy management and use of renewable sources is apparent for Priority Axis 3 ‘Efficient energy management, development of energy infrastructure and renewable energy sources, support for the introduction of new technologies in the management of energy and secondary raw materials’. The Priority Axis 3 covers 28.1% of the allocation of the OP EIC and is directly linked to the fulfilment of selected key objectives of the Europe 2020 strategy.

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;
- The total program budget for energy savings and of RES support is CZK 19 bill. (approx. EUR 730 mill.).

The specification of aid conditions within the OP EIC include an obligation to comply with sustainable development. Compliance with the principles of sustainable development is required at the individual project level of interventions involving construction works, purchase of technology, equipment, appliances, i.e. interventions showing a high probability of impacts on the environment or efficient use of resources (in particular energy resources), investments in scope of such interventions have to meet the highest standards. As a general rule, no projects with adverse effects on sustainable development will be promoted under the OP EIC. The OP EIC also contains environmental indicators which are monitored for relevant specific objectives at the project level, to be further aggregated for the needs of the Partnership Agreement. Environmental indicators mainly concern the indicator ‘Reduction in final energy consumption in supported entities’, ‘Additional capacity of renewable energy production’, ‘Estimated annual decrease of GHG’, ‘Reduction in emissions of primary particles and secondary particulate precursors’ and other related indicators. In connection with the termination terms of physical realization of supported projects these indicators have not begun to be fulfilled so far. Estimated energy saving in this period is about 20 PJ.

Type of policy: Economic (subsidies)

Implementing entity: Ministry of Industry and Trade (Government)

Period of implementation: 2014-2020

Implemented in scenario: WEM

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

Table 4.40 Expected energy savings of the programme Operational Programme Enterprise and Innovation for Competitiveness

	2020	**2025**	**2030**	**2035**	**2040**
Energy savings [TJ]	10 640	13 030	13 030	13 030	13 030

Source: CHMI

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.

Table 4.41 Expected emissions reduction resulting from energy savings of the programme Operational Programme Enterprise and Innovation for Competitiveness

	2020	**2025**	**2030**	**2035**	**2040**
Emissions reduction [kt CO_2 eq.]	799.37	1160.04	1122.63	1045.09	893.72

Source: CHMI

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:

Table 4.42 Expected energy production from RES and corresponding emissions reduction of the programme Operational Programme Enterprise and Innovation for Competitiveness

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

Source: CHMI

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

Sectors: Energy

Greenhouse gas coverage: CO_2

n) OP Technology and application for competitiveness (OP TAC) 2021 – 2027

Managing body: Ministry of Industry and Trade of the Czech Republic

Subsidy grant and FI (combination primarily aimed at SME, big companies e.g. energy sectors and research and development). It is financed from ERDF.

The main goals are:

- negative impact of pandemic mitigation
- increase of productivity of Czech enterprises
- environmental aspects

Area is all regions except Prague

Total allocation of OP TAC is total 3 136 mil Euro.

There is Priority 4 shift to law carbon economy. The allocation of this priority is 29 billion CZK.

Specific axis 4.1 Support of energy efficiency and CO2 reduction

Allocation: roughly 0,5 billion EUR

Indicative target: 3,3 PJ energy savings

Expected CO_2 reduction is 349 000 t CO_2 eq

Measures: Reducing of the energy intensity of buildings (insulation and increase of energy efficiency of technical equipment of the building), modernization of boilers for own consumption except gas boilers, increase energy efficiency of technologies, RES for own consumption (heat pumps , PV, solar collectors , biomass boilers) within complex projects, cogeneration and Ecological and innovative renewal of traction rail vehicles and Modernization of traction substations and traction supply networks (New activity).

Specific axis 4.2 Support of energy from RES

Allocation: roughly 0,26 billion EUR

Indicative target: 202 MW total installed capacity

Expected CO_2 reduction is 238 103,77 t CO_2 eq.

Measures: Heat Pumps, PVE, Wind, hydro, biogas, biomass

o) Modernisation Fund

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

In early 2021 the Czech government approved the programming document for the Modernisation Fund and first calls for project proposals were open in 2021. The Modernisation Fund was designed to be complementary to other national support programmes and operational programmes.

The financial support will be provided in the following areas:

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

Type of policy: Economic (subsidies)

Implementing entity: Ministry of Environment Government)

Period of implementation: 2021-2030

Implemented in scenario: WAM

Mitigation impact: The expected programme energy savings are shown in the following table.

Table 4.43 Expected GHG savings of the Modernisation Fund

	2020	2025	2030	2035	2040
Energy savings [TJ]	2 905	4 375	17 500	17 500	17 500

Source: MoE

Sectors: Energy, Manufacturing industries and construction,

Greenhouse gas coverage: CO_2, CH_4

4.3.2 Industrial Processes and Product Use

<u>Policies and Strategies</u>

The Czech Republic does not have one comprehensive industrial strategy or policy. Instead, it has more sub-strategies focused on specific areas. The Industry 4.0 document adopted by the Government in 2016 can also be understood as a partial strategy of industrial development in the Czech Republic. Many of these strategies focus on the relationship between industry and environmental protection. Those that affect greenhouse gas emissions are described below.

Ozone layer protection

Policies and strategies adopted in the field of ozone layer protection were adopted back in 2004 and 2005. They were aimed at the timely phase out of certain uses, notably the CFCs in metered dose inhalers, HCFCs in the refrigeration and air conditioning (henceforth as "RAC") sector, and halons in the fire-fighting sector. The objective of all respective strategic documents were met, thus all those were made obsolete roughly by the year of 2015. The only strategic document that has been recently "revived" is the one aimed on the use of halons in the fire-fighting sector. The Ministry of the Environment has adopted a new strategic document with the objective of collection/destruction/regeneration of the remaining halons being still installed in certain critical use applications. The underlying objective is the full phase-out of all critical use applications by the year 2040.

The implementation of the F-gas regulation is not subject to any strategic document. The national legislation implements both the F-gas and the Ozone Depleting Substances (henceforth as "ODS") regulation with their main objectives:

- To make both regimes identical for the "end user ";
- To adhere strictly to the minimum EU requirements on the qualification of personnel and make them applicable both to the ODS and F-gasses in the same manner;
- To keep the recovery criteria of ODS and F-gases from refrigeration and firefighting equipment as strict as possible, beyond the EU legislation.

<u>Legislative Instruments</u>

a) Act No. 76/2002 Coll., on integrated pollution prevention and control, on the integrated pollution register (Integrated Prevention Act), as amended

Integrated pollution prevention and control, abbreviated as IPPC, refers to the minimising of pollution from various industrial sources throughout the EU. The Integrated Prevention Act, as amended, transposes EU legislation, at the beginning Directive 96/61/EC (later replaced by codified wording under No. 2008/1/EC) on Integrated Pollution Prevention and Control (henceforth as "IPPC"). The current Directive 2010/75/EU on industrial emissions (integrated pollution prevention and control) have been transposed into national legislation in 2013 according to Article 80(1) of the Directive by amending the Act. The Regulation requires industrial and agricultural activities with a high pollution potential to have a permit; this permit can only be issued if certain environmental conditions are met, so that the companies themselves bear responsibility for preventing and reducing any pollution they may cause. The IPPC Directive is based on several principles, namely an integrated approach, best available techniques, flexibility and public participation. The implementing regulation to Act No. 76/2002 Coll. is regulation No. 288/2013 Coll. The main objective of integrated prevention is protection of the environment as a whole against industry and agriculture pollution by regulation of operations of selected facilities listed in Annex No. 1 of the Act. Issuance of integrated permit replaces several other administrative acts according to corresponding legislation.

Prevention of pollution by implementing the so-called best available techniques (henceforth as "BAT") represents a higher degree of protection of the environment.

In the area of greenhouse gas emissions, which are generated by production and use of heat and electricity, the Act allows the regulator to apply the BAT concept, which should lead to increased energy efficiency of production. BAT includes technologies used as well as the manner in which the facility is designed, built, operated, maintained and decommissioned. This Act also allows application of emission limits or equivalent technical parameters, which are based on advanced technologies used in affected industrial sectors. Nevertheless, the possibility of imposing emission limits directly with respect to greenhouse gas emissions remains limited by law on integrated prevention only in cases where it is required, in order to prevent serious pollution at the site.

The manner and scope of ensuring information exchange by BAT is defined in Act No.76/2002 Coll., on integrated prevention, as amended. The set of BAT is specified in reference documents (BREF). For permitting purposes, the most important information is provided in the so-called conclusions on BAT.

Type of policy: Regulatory

Implementing entity: Ministry of Environment (Government)

Period of implementation: Since 2002

Implemented scenario: WEM

Mitigation impact: As this is a framework measure, its mitigation effect is accounted under other measures.

Sector: Industrial Processes

Greenhouse gas coverage: CO_2, CH_4, HFCs, PFCs, SF_6

b) Regulation (EU) No. 517/2014 on fluorinated greenhouse gases and repealing Regulation (EC) No. 842/2006

The F-Gas Regulation (EU) No 517/2014 retains many important and successful features of the previous F-Gas Regulation related to leak prevention, F-gas recovery and technical training. As its main measure is to reduce the use of HFCs, the new Regulation prescribes a cap and subsequent reduction of HFCs that can be placed on the EU market (“phase-down”). The new F-Gas Regulation also includes several bans. F-gases with high global warming potential (henceforth as “GWP”) are restricted from use in new equipment in refrigeration, small air conditioners, fire protection, foams and technical aerosols. In addition, a “service ban” requires operators of existing equipment to start using more climate-friendly alternatives from 2020 onwards.

The main scope of the F-gas regulation:

- 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.

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

Type of policy: Regulatory

Implementing entity: Ministry of the Environment (Government)

Period of implementation: 2015-2035

Implemented scenario: WEM

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

Sector: Industrial Processes

Greenhouse gas coverage: HFCs, PFCs, SF_6

c) Act No. 73/2012 Coll., on ozone depleting substances and fluorinated greenhouse gases, as amended

This Act regulates the rights and obligations of persons and competence of administrative bodies in the field of ozone layer protection and climate system protection against negative effects of regulated substances and fluorinated greenhouse gases. The implementing regulation to Act No. 73/2012 Coll., as amended, is regulation No. 257/2012 Coll., on emission prevention of substances damaging ozone layer and fluorinated greenhouse gases.

With regard to ozone layer protection, the fundamental regulation is Regulation (EC) No.1005/2009 of the European Parliament and of the Council of September 2009 on substances that deplete the ozone layer, as amended, and Regulation (EU) No. 517/2014 of the European Parliament and of the Council of April 2014 on fluorinated greenhouse gases and repealing Regulation (EC) No. 842/2006.

A process of amending this Act is to be finalised soon, the main objective being the removal of non-refillable containers from the black market by means of banning their use and storage; newly the conditions for reclamation of fluorinated gases will be introduced. Only undertaking holding permission of the Ministry of the Environment will be allowed F-gases reclamation.

Type of Policy: Regulatory

Implementing entity: Ministry of the Environment (Government)

Period of Implementation: Since 2012

Implemented Scenario: WEM

Mitigation impact: The Act aims to remove substances that deplete the ozone layer.

Sector: Industrial Processes

Greenhouse gas coverage: HFCs, PFCs, SF_6

d) Directive 2006/40/EC (MAC Directive)

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

Type of policy: Regulatory

Implementing entity: Ministry of Transport (Government)

Period of implementation: Since 2008

Implemented in scenario: WEM

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.

Sector: Industrial Processes

Greenhouse gas coverage: HFCs

e) The Kigali Amendment to the Montreal Protocol

The Kigali Amendment was agreed at the 28th Meeting of the Parties to the Montreal Protocol on Substances that Deplete the Ozone Layer in October 2016. 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. Trade with Parties that have not ratified the Amendment ("non-Parties") will be banned from 1 January 2033.

Type of policy: Regulatory

Implementing entity: Ministry of the Environment (Government)

Period of implementation: 2019-2036

Implemented in scenario: WEM

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 the 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.

Sector: Industrial Processes

Greenhouse gas coverage: HFCs

Financial Schemes and Programmes

An Eco tax on imports and the use of ODS has been introduced back in 2002 and it is still in place, even though it is applied on very rare occasions as ODS have been phased out completely apart from the critical use applications.

Finances that have been acquired by means of this eco tax are used (to this day) mostly for supporting the recovery and destruction of ODS. The dominant sector being the halon installations, the RAC were supported by these means as well. Domestic RAC is, however, a subject to a take-back scheme under the waste regulation (WEEE Directive), so the recovery and destruction costs are covered by the buyers of new equipment. The reason for the above-mentioned preference of halons is their very high ozone depleting potential and the fact that their release into atmosphere is technically identical with their intended use. The support continues to be provided to these days.

Type of policy: Regulatory

Implementing entity: Ministry of Finance (Government)

Period of implementation: Since 2002

Implemented in scenario: WEM

Mitigation impact: The Act aims to remove substances that deplete the ozone layer.

Sector: Industrial Processes

Greenhouse gas coverage: HFCs, PFCs, SF_6

4.3.3 Agriculture

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 include optimal timing of fertilization, the exact amount of fertilizer application to crop use and optimal (covered) storage of manure.

The EU Common Agricultural Policy (henceforth “CAP”) has a significant impact on the extent, orientation and profitability of agricultural activities. The CAP is based on three principles – a common market for agricultural products based on common prices, preferences for agricultural production in EU countries as opposed to external competition, and financial solidarity - financing from common contribution-based funds. 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.

With the new CAP after 2020 there has been published 3 new regulations in December 2021:

- Regulation (EU) 2021/2115 of the European Parliament and of the Council of 2 December 2021 establishing rules on support for strategic plans to be drawn up by Member States under the common agricultural policy (CAP Strategic Plans) and financed by the European Agricultural Guarantee Fund (EAGF) and by the European Agricultural Fund for Rural Development (EAFRD) and repealing Regulations (EU) No 1305/2013 and (EU) No 1307/2013
- Regulation (EU) 2021/2116 of the European Parliament and of the Council of 2 December 2021 on the financing, management and monitoring of the common agricultural policy and repealing Regulation (EU) No 1306/2013
- Regulation (EU) 2021/2117 of the European Parliament and of the Council of 2 December 2021 amending Regulations (EU) No 1308/2013 establishing a common organisation of the markets in agricultural products, (EU) No 1151/2012 on quality schemes for agricultural products and foodstuffs, (EU) No 251/2014 on the definition, description, presentation, labelling and the protection of geographical indications of aromatised wine products and (EU) No 228/2013 laying down specific measures for agriculture in the outermost regions of the Union

In the period to 2020, EUR 8.3 billion will be invested from the EU budget into the Czech farming sector and rural areas. The total budget available for Czech farmers in the form of Direct Payments is EUR 6.01 billion while around EUR 2.31 billion has been allocated for measures benefiting its rural areas (including transfers from Direct Payments), which is then supplemented by further public and private funding.

Policies and Strategies

a) Action Plan for Biomass in the Czech Republic for the period 2012-2020

The main aim of the Action Plan for Biomass was to set up appropriate measures and principles that supported sustainable use of the energy potential of biomass in the Czech Republic. The main objectives included a determination of energy potential of agricultural and forest woody biomass and quantifying the amount of energy that could be produced by biomass in the Czech

Republic by the year 2020. Action Plan for Biomass has expired at the end of 2020 year. Since 2021 was replaced by National Renewable Energy Action Plan (NREAP), which included also energy production from biomass.

Type of policy: Fiscal

Implementing entity: Ministry of Agriculture (Government)

Period of implementation: 2012-2020

Implemented scenario: WEM

Mitigation Impact: Expected GHG emissions reduction was approximately 125 kt CO_2 eq.

Sectors: Agriculture, Energy, LULUCF

Greenhouse gas coverage: CO_2

b) Czech Action Plan for Development of Organic Farming 2016-2020

The aim of the Action Plan for the Development of Organic Farming 2016-2020 (henceforth "AP") was to support the development of organic farming in the Czech Republic until the year 2020, and was developed as the third AP in succession. This AP is followed by the new Action Plan for the Development of Organic Farming 2021-2027. Organic farming (henceforth "OF") has been developing in the Czech Republic for more than 25 years. Areas such as legislation or inspection and certification systems are agreed on at a high level, but other areas are not yet sufficiently developed (e.g. organic food processing and sale, domestic organic food market, use of OF potential in the area of nature protection, research and innovation in OF, consultancy and education) and require systematic support. A new AP has been drawn up for this purpose. It includes priority areas and recommended measures and its implementation will contribute to the further development of OF. The defined priority areas for OF development up to the year 2020 are based on an analysis of the current state of OF and an updated SWOT analysis. Specifically, the defined priority areas for OF including their strategic goals for the time period 2016-2020, as stated and further described together with priority measures in the Action Plan, are:

1. Organic Farms – Improve the economic viability of organic farms;
2. Organic Food Market – Increase the proportion of Czech organic foods on the market;
3. Consumption of organic foods – Increase the consumption of organic foods, especially of Czech origin;
4. Benefits to the environment and animal welfare – Raise awareness of the benefits of the OF to the environment and animal welfare;
5. Research – education – consultancy – Increase the use of research results and innovation.

Overall, the main aims of the Action Plan are the following:

- Organic farming will become an important part of Czech agriculture = the aim is to increase the viability of organic farms while concurrently retaining the benefits for the environment and animal welfare (fair prices along with effective and considerate methods of organic production);

- Build a stable market for organic foods with a significant proportion of foods of Czech origin (produced from domestic organic raw ingredients) = raise consumer confidence and consumption of organic foods;
- Functional cooperation within the entire supply chain (functional sales).

Type of policy: Fiscal

Implementing entity: Ministry of Agriculture (Government)

Period of implementation: 2016-2020

Implemented scenario: WEM

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

Sector: Agriculture

Greenhouse gases coverage: CH_4, N_2O

c) Strategy for Growth – Czech Agriculture and Food Sector within the Common Agricultural Policy of the EU after 2013

The Strategy for Growth layed down strategic development targets in the field of agriculture and food production for the Czech Republic. 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.) was taken into account, also ensuring adequate market share for the production of processed agricultural and food products, especially those for which there is a potential for competitive production.

The document presented prognosis of activity data and agricultural management targets in the context of agro-environmental measures and policies.

In the field of agriculture, the main objective is to contribute on a long-term and sustainable basis to the food security on the national and European level and to contribute to the energy self-sufficiency of the Czech Republic within the framework of the set energy mix and rural development, including the increase of its recreational potential. Out of the seven targets to this objective, several of them were closely linked to mitigation efforts – e.g., to develop the use of agricultural production and waste as renewable sources of energy, or to improve the impacts of agriculture on natural resources and, in times of climate change, to increase protection with regard to sustainable farming, comprehensive development, and landscape creation. Validity of this strategy finished in 2020 year and was not prolonged or replaced.

Type of policy: Fiscal

Implementing entity: Ministry of Agriculture (Government)

Period of implementation: 2013-2020

Implemented in scenario: WEM

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

Sector: Agriculture

Greenhouse gas coverage: CH_4, N_2O, CO_2

d) The Strategy of the Ministry of Agriculture of the Czech Republic with outlook up to 2030

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 via relevant programmes. The document was approved by the Government of the Czech Republic in May 2016.

Type of policy: Fiscal

Implementing entity: Ministry of Agriculture (Government)

Period of implementation: 2016-2030

Implemented in scenario: WEM

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

Sector: Agriculture

Greenhouse gas coverage: CH_4, N_2O

Legislative Instruments

a) Cross Compliance

Cross compliance has been employed in the Czech Republic since January 2009. Based on this mechanism, direct payments and other selected subsidies can be granted only on the condition that a beneficiary meets the statutory management requirements addressing environment, public health, the health of animals and plants, and animal welfare, the standards of Good Agricultural and Environmental Conditions (GAEC). In the following years, the cross compliance mechanism underwent a number of updates reflecting the EU legislation; the requirements and evaluated standards within Cross Compliance were updated in line with the Common Agricultural Policy.

Type of policy: Research, Education

Implementing entity: Ministry of Agriculture (Government)

Period of implementation: 2009-2035

Implemented in scenario: WEM

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

Sector: Agriculture

Greenhouse gases coverage: CH_4, N_2O, CO_2

b) Nitrates Directive – Czech Republic's 4th Action Programme

The Nitrates Directive (91/676/EEC) generally requires EU 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 programme should be applied to protect waters from pollution by nitrates from agricultural sources;
- Develop and implement action programmes to reduce and prevent this pollution in identified areas: action programmes are to be implemented and updated on a four-year cycle;
- Monitor the effectiveness of the action programmes 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).

The Czech Republic has drawn up action programmes to reduce nitrate pollution. The 4th Action programme was in force for the period from August 2016 to June 2020. A technical update of the Action Programme was carried out in March 2018. Based on the update, changes have been made in respect to seasons and limits of fertilization use, agricultural activities in proximity to surface water, crop rotation, storage of fertilizers, farming on slopes and farming near water. Altogether, the programme as such focuses on defining vulnerable areas, their revision and expansion. In the 5th Action Programme, which has been in force since July 2020, measures have been introduced to restrict the cultivation of maize in rotation, whereby this crop cannot be cultivated in application zone III. for more than 2 consecutive years. And there is the obligation to prepare a nitrogen balance for farmers farming in nitrate vulnerable areas. It should be noted that the costs associated with the 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.

Type of policy: Information

Implementing entity: Ministry of Agriculture (Government)

Period of implementation: 2016-2035

Implemented in scenario: WEM

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

Sector: Agriculture

Greenhouse gas coverage: N_2O

<u>Financial Schemes and Programmes</u>

a) Czech Rural Development Programme for 2014-2020

The Rural Development Programme (RDP) for the Czech Republic was formally adopted by the European Commission in May 2015, outlining the Czech priorities for using the nearly EUR 3.1 billion of public money that is made available for the 7-year period 2014-2020. Of this budget, EUR 2.3 billion comes from the EU budget with EUR 135 million transferred from the envelope for CAP direct payments, and EUR 769 million of national co-funding. Regulation (EU) 2020/2220 of the EP and of the Council of 23.12.2020 prolonged the programming period to 2022. In 2021, within the 9th RDP modification, the national contribution was increased with the total public contribution reaching more than EUR 4.7 billion (EUR 3.1 billion from the EU budget and EUR 1.7 billion of national co-funding).

The RDP focuses mainly on ensuring the sustainable management of natural resources and on encouraging climate friendly farming practices, with around 25% of agricultural land under contract to protect biodiversity, 11% to improve water management and 12% to protect soil. Secondly, its aim is to increase the competitiveness of agriculture and forestry as well as that of the food industry. The RDP also supports organic farming, increased use of renewables, and afforestation of agricultural land. The objective of the programme is thus 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, and to improve landscape infrastructure.

The RDP funds actions under six Rural Development Priorities and in the Czech context, particular emphasis is placed on Priority 4: Restoring, preserving and enhancing ecosystems related to agriculture and forestry. Under this priority, among other activities, nearly 870 000 ha of farmland will be subject to voluntary agri-environmental and climate-related commitments by farmers, who will receive training on the better delivery of environmental and climate-related benefits. Priority 5: Resource efficiency and climate is further relevant as under this priority the RDP will support renewable energy investment to produce wooden pellets and the afforestation of 250 ha of agricultural land to increase CO_2 sequestration.[17]

In general, 61.26% of public support is directed towards Priority 4 with 25.75% being used for agri-environment-climate measures in the context of water management. On the other hand, 0,26% of public support is spent on Priority 5 related to promoting resource efficiency and supporting the shift towards a low carbon and climate resilient economy in agriculture, food and forestry sector (renewable energy and carbon conservation/sequestration).

In the next period will follow CAP SP 2023-2027, targeting the same priorities and objectives specifically specific objective 5: “Fostering sustainable development and efficient management of natural resources such as water, soil and air, including by reducing chemical dependency” (SO 5) with proposed budget EUR 2.2 billion for Eco-schemes, Organic farming, Agri-environmental and climate-related management and Land consolidations from the total of EUR 7.9 billion total public expenditures.

Type of policy: Fiscal

Implementing entity: Ministry of Agriculture (Government)

Period of implementation: 2014-2020

Implemented in scenario: WEM

[17] https://ec.europa.eu/agriculture/sites/agriculture/files/rural-development-2014-2020/country-files/cz/factsheet_en.pdf

Mitigation impact: It is expected that GHG emissions reduction in 2020 will be approximately 200 kt CO_2 eq. and 357 kt CO_2 eq. in 2035.

Sectors: Agriculture, LULUCF

Greenhouse gas coverage: CO_2, CH_4, N_2O

4.3.4 LULUCF

The land use, land use change and forestry (LULUCF) sector is linked to agriculture and some of the policies listed above in the chapter on Policies and Measures in the Agriculture Sector are partly common for both sectors. Policies and measures in the LULUCF sector are generally focused on the sustainable use of natural resources, biodiversity preservation, and on 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, emissions and removals. Their effect on greenhouse gas balance of the LULUCF sector may be indirect, however, not practicably quantifiable. Similarly, the adopted EU 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 (henceforth "FRL"). Setting FRL is mandatorily based on the 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 experiencing an unpreceded large-scale decline of spruce-dominated stands (and also other species are endangered by recurrent drought), the adopted accounting framework becomes very unfavourable for the national circumstances. This issue is expected to 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 the 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.

Policies and Strategies

a) State forestry policy until 2035

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 (Act no. 289/1995 Coll. on Forests and Amendments to some Acts), which is the principal legislative instrument in this regard. This instrument also does not specifically target carbon balance, but its provisions affect carbon budget and greenhouse gas emissions and removals in numerous ways indirectly.

Beyond the legislation above, State forestry policy until 2035 is the basic national strategic document for forestry and forestry-related sectors. It includes specific 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 legislation.

Several of these recommendations are continuously being implemented according to the Decree No 298/2018/ Coll., on elaborating regional plans of forest development and on specification of economic complexes. The Decree has increased the minimal share of improving and stabilizing tree species (newly including larch and Douglas fir) in the forest stands. It has also increased the financial support for improving and stabilizing species and introduced support for pioneering species to speed up forest regeneration. Provisions of this decree are implemented through regional plans of forest development which are currently undergoing the process of update.

Type of policy: Economic

Implementing entity: Ministry of Agriculture (Government)

Period of implementation: 2021-2035

Implemented in scenario: WEM

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 a century. The key aim of the above policies is the 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 program 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.

Sector: LULUCF

Greenhouse gas coverage: CO_2

<u>Legislative Instruments</u>

a) **Regulation (EU) No. 2018/841 on the inclusion of greenhouse gas emissions and removals from land use, land use change and forestry into the 2030 climate and energy framework**

To ensure the contribution of the LULUCF sector to the achievement of the European Union's emission reduction target of at least 40% cuts in greenhouse gas emissions (from 1990 levels) and to the long-term goal of the Paris Agreement, the LULUCF Regulation has established a robust accounting system for the different LULUCF land accounting categories for the period

2021-2030 in accordance with the 2006 IPCC Guidelines. The Regulation sets a binding commitment for each Member State to ensure that accounted emissions from land use are entirely compensated by an equivalent removal in the LULUCF sector (so called "no debit" rule). For the key category of managed forest land, it has established accounting based on forest reference levels, which should not take into account any new forestry policies adopted after 2009.

Currently the legislative procedur for the revision of Regulation (EU) 2018/841 on emissions and removals from land use, land-use change and forestry is almost completed. The revision sets a new EU level target of increasing removals to -310 million tonnes of CO_2 eq in 2030. This target is distributed between the Member States and the respective target for the Czech Republic for 2030 is -1 228 kt CO_2 eq. The Member States also need to comply with a carbon budget for 2026-2029.

Type of policy: Regulatory

Implementing entity: Ministry of Agriculture (Government)

Period of implementation: 2021-2030

Implemented in scenario: WEM

Mitigation impact: The LULUCF accounting framework has no direct mitigation impact. However, it should encourage Member States to maintain and enhance their carbon sink. The credits from LULUCF accounting could be to a limited degree used for Effort Sharing Regulation compliance and, on the other hand, the debits resulting from non-compliance with the "no debit" rule need to be compensated by Annual Emission Allocations (AEAs). According to the proposed revision this compensation will be only required in the 2021-2025 period.

Sector: LULUCF

Greenhouse gas coverage: CO_2, CH_4, N_2O

4.3.5 Waste

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 municipal solid waste (henceforth as "MSW") and unfavourable mix of MSW treatment options. Recently, this trend started to change and we observe mild stagnation of emissions from landfills, which is a key source of GHG emissions from this sector in the Czech Republic. The slowing of GHG production observed is mainly due to increased landfill gas (henceforth as "LFG") capturing.

There is a potential for emission reductions in fulfilling the EU obligations of the Circular Economy Package (henceforth as "CEP") (COM/2015/0614) and other national measures with emission reduction effects related to the national common waste policy. Waste-to-energy 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, significant reduction of landfilled waste, minimizing the delivery of biodegradable waste in landfills, establishing and expanding separate collection system for different waste streams (plastics, paper, glass, bio-waste, cardboard, metals, textile), promoting the energy recovery and digestion of non-recyclable waste, and increasing landfill gas recovery.

The Czech waste legislation is largely based on the EU legislation. The EU legislation with direct impact on GHG emissions from waste included the Landfill Directive (1999/31/EC) and the Waste Directive (2008/98/EU), these Directives have been modified by the CEP. The revised legislative framework on waste has entered force in July 2018. The EU Member states have 24 months to implement the CEP into national law.

There are several policies that are not part of the 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, nevertheless, it is important to especially highlight the EU ETS, the Climate & Energy Package and the Energy Tax Directive which provide direct and indirect support on LFG recovery and therefore significantly influence landfill emissions.

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

Policies and Strategies

a) Waste Management Plan of the Czech Republic for the period 2003-2014

The most important instrument on the national level aimed at CH_4 emission reduction from waste was the Waste Management Plan (henceforth "WMP"). All of the targets and measures were in compliance with the obligatory EU legislation. Further, several programmes were set up to help reach the WMP goals. The main programme was the OPE 2007-2013 with its priority axis 4: Improvement of waste management and rehabilitation of old ecological burdens. This axis had a budget of EUR 713 million from the EU Cohesion Fund.

The increasing share of recovered waste to the waste disposed is the result of three factors: 1. A shift towards more efficient technology use in the manufacturing sector 2. Waste is perceived as a source of raw material 3. The financial support of EUR 713 million from the OPE 2007-2013 has helped implement the WMP as EUR 515 million was allocated to waste management alone. The total number of supported projects in this context reached 4227.

The tables below show the rates of municipal waste treatment and treatment with all waste in the Czech Republic for the time period 2009-2014. The time period begins from 2009 as the official database VISOH, operated by the Ministry of Environment, shows values from 2009.

Table 4.43 Municipal waste treatment in the Czech Republic in 2009-2014

Municipal Waste	Recovery	Material recovery	Energy recovery	Landfilling	Other treatment
Year 2009	29%	23%	6%	64%	7%
Year 2010	33%	24%	9%	59%	8%
Year 2011	42%	31%	11%	55%	3%

Municipal Waste	Recovery	Material recovery	Energy recovery	Landfilling	Other treatment
Year 2012	42%	30%	12%	54%	4%
Year 2013	42%	30%	12%	52%	6%
Year 2014	47%	35%	12%	48%	5%

Source: MoE

Table 4.44 Treatment of all waste in the Czech Republic in the period 2009-2014

All waste	Recovery	Material recovery	Energy recovery	Landfilling	Other treatment
Year 2009	74.5%	72.5%	2%	15%	10.5%
Year 2010	73.5%	71%	2.5%	13.5%	13%
Year 2011	78%	75%	3%	13%	9%
Year 2012	79%	75.5%	3.5%	13%	8%
Year 2013	79.5%	76%	3.5%	11%	9.5%
Year 2014	83%	79.5%	3.5%	10%	7%

Source: MoE

Type of policy: Economic, Fiscal

Implementing entity: Ministry of the Environment (Government)

Period of implementation: 2003-2014

Implemented in scenario: WEM

Mitigation impact: The total emission reduction of this measure is 974 kt CO_2 eq. in 2035.

Sector: Waste

Greenhouse gas coverage: CH_4

b) Waste Management Plan of the Czech Republic for the period 2015-2024

Today's crucial instrument in the context of waste management on the national level is the Waste Management Plan (WMP) for the period 2015-2024 adopted by the Government in December 2014.

The WMP of the Czech Republic establishes in accordance with the principles of sustainable development the objectives, policies, and measures of waste management in the Czech Republic. The WMP is also the reference document for the development of regional Waste Management Plans. The binding part of WMP constitutes the mandatory basis for decision-making and other activities of the relevant administrative authorities, regions, and municipalities in the area of waste management. The WMP has been prepared for the period of 10 years, and will be changed immediately following any fundamental change in the conditions under which it had been developed (e.g. new legislation on waste management affecting the waste management strategy, including the establishment of new objectives or the redefinition of existing objectives, policies, and measures).

From 2024, certain waste categories (recyclable and recoverable wastes) will be prohibited from being deposited in landfills. For these categories, the landfilling fee will be gradually increased to achieve gradual decrease in the quantity of waste from the relevant categories deposited at landfills.

The defined objectives and targets set in the WMP 2015-2024 include, also in light of the European Directive 2008/98/EC on waste, the following:

- In relation to municipal waste, to introduce by the year 2015 separate collection at least for waste consisting of paper, plastic, glass, and metals; (from 2015 is obligatory separate collection of biodegradable municipal waste and from 2020 is obligatory separate collection of edible oils and fats);

- By 2020, the preparing for re-use and the recycling of waste materials such as at least paper, metal, plastic and glass from households and possibly from other origins as far as these waste streams are similar to waste from households, shall be increased to a minimum of overall 50% by weight.

- To use mixed municipal waste (after sorting of materially recoverable components, hazardous substances and biodegradable waste) especially for energy recovery in facilities designed for this purpose in accordance with effective legislation;

- To reduce the maximum quantity of biodegradable municipal waste deposited at landfills in such a way, so that the share of this component would in 2020 account for maximum of 35% by weight of the total quantity of biodegradable municipal waste produced in 1995;

- To increase by the year 2020, to at least 70% by weight, the rate of preparing for re-use and the rate of recycling of construction and demolition waste and other types of their material recovery;

- Objectives are also set for packaging and packaging waste, separate collection of waste electrical and electronic equipment, waste batteries and accumulators, and for the processing of end-of-life vehicles and waste tyres.

The OPE 2014-2020 is a direct continuation of the above mentioned OPE 2007-2013 and it is also financed from the EU Cohesion Fund. The priorities of the project support in waste management are determined by the obligations set in the CEP (COM/2015/0614), the WMP and by the Programme of Waste Prevention of the Czech Republic. Waste management and material flows, environmental burdens and risks are covered by the OPE's Priority Axis 3. From the Priority Axis 3's overall budget of EUR 458.8 million, for example EUR 18.3 million is allocated for preventing municipal waste generation, EUR 42.7 million for preventing industrial waste generation, EUR 68 million for construction and modernization of waste collection, sorting and treatment facilities, EUR 103 million for material recovery of waste, EUR 53 million for energy recovery of waste and EUR 22.2 million for construction and modernization of hazardous waste management facilities.

The new WMP includes modelling of the proposed and implemented measures and their impact on activity data – waste quantity and waste management practices. The result of this modelling was used as a basis for the projections of GHG emissions in this document.

Type of policy: Economic, Fiscal

Implementing entity: Ministry of Environment (Government)

Period of implementation: 2015-2024

Implemented in scenario: WEM

Mitigation impact: The assumption for GHG emission reduction is 0.56 Mt CO_2 eq. or 10% over the period of 2015-2024

Sectors: Waste, Energy

Greenhouse gas coverage: CH_4

<u>Legislative Instruments</u>

a) Circular Economy Package

In 2015, the European Commission published an ambitious Circular Economy Action Plan (COM/2015/0614) which includes measures that will help stimulate Europe's transition towards a circular economy. In July 2018, the revised waste legislative framework has entered force setting clear targets for reduction of waste and the establishment of a long-term path for waste management and recycling.

Key elements of the revised waste proposal, the Circular Economy Package (CEP), include:

- A common EU target for recycling 65% of municipal waste by 2035;
- A common EU target for recycling 70 % of packaging waste by 2030;
- A binding landfill target to reduce landfill to maximum of 10% of municipal waste by 2035;
- Recycling targets for specific packaging materials;
- Strengthening and extension of separate collection obligations to hazardous household waste (by the end of 2024), bio-waste (by end of 2023), textiles (by the end of 2024), etc.
- Establishment of minimum requirements for extended producer responsibility schemes to improve their governance and cost efficiency;
- Promotion of economic instruments to reduce landfilling;
- Improved definitions and harmonised calculation methods for recycling rates throughout the EU;
- Specific 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.

Time of policy: Economic, Fiscal

Implementing entity: Ministry of Environment (Government)

Period of implementation: 2018-2035

Implemented in scenario: WEM

Mitigation impact: The assumption is that obliging with the CEP 2030 targets will also significantly contribute to the achievement of GHG reduction target.

Sector: Waste

Greenhouse gas coverage: CH_4

4.3.6 Transport

Policies and Strategies

a) National Action Plan for Clean Mobility

The National Action Plan for Clean Mobility (henceforth "NAP CM") for the period 2015-2018 with the outlook until 2030 responds to the Directive 2014/94/EU on the deployment of alternative fuels infrastructure. The Directive requires the development of domestic policy framework to support the growth of the market with alternative fuels within the transport sector as well as the development of related infrastructure.

The NAP CM focuses on electromobility, CNG, LNG, and partly also hydrogen technology (or the technology of fuel cells). Due to the direct relation to the above-mentioned Directive, the NAP CM primarily aims at alternative fuels, which are underlined in the Directive as being crucial for EU Member States, as well as the need to define, within domestic policy frameworks, national targets for the development of related infrastructure of charging and filling stations. The NAP CM sets out requirements for the construction of filling and charging stations with a time horizon between 2020 and 2030. Specifically, based on the Directive, 1 300 charging stations have to be in use by the year 2020 as well as 3-5 hydrogen filling stations. Concerning strategic goals in relation to electromobility, they include the facilitation of infrastructure development in the field of electromobility, the stimulation of demand for electric vehicles, the creation of conditions for potential customers to perceive electric vehicles in a better light, and to improve conditions to conduct business in fields related to electromobility.

The emphasis of the NAP CM is in accordance with the effort to strive mainly for technologies close to commercial use. The document will be updated every three years as required by the Directive.

By creating the NAP CM, the Government of the Czech Republic declares its will to support the development of alternative fuels in transport and thus to help achieve goals in the area of energy, transport, and environment. Reflecting the Directive, a key principle of the NAP CM is technical neutrality, which means the public sector's untargeted preference towards only one type of alternative fuels. To achieve planned emission reduction in the transport sector, it is necessary to increase the share of alternative fuels. Based on predictions, the biggest impact on the reduction of GHG emissions by the year 2020 in the transport sector in the conditions of the Czech Republic will be reached predominantly via the use of CNG.

Concerning clean mobility as such, it is financed, as stated in the NAP CM, via several subsidy programmes:

- Operational Programme Transport – helps fund infrastructure for alternative fuels
- Operational Programme Enterprise and Innovation for Competitiveness – helps fund the purchase of electric cars for entrepreneurs
- Integrated Regional Development Programme – helps fund the purchase of buses using alternative fuels
- National Programme of the Ministry of Environment of the Czech Republic to help purchase municipalities vehicles using alternative fuels

These programmes are described in more detail in the relevant section (Programming Tools and Other Measures).

The NAP CM was updated in 2020 taking into account:

- The CO_2 emission standards for new vehicles
- The goal of 14% RES share in the transport sector
- Binding national targets for public procurement of clean vehicles (Clean Vehicles Directive)
- New EU funds programming period

The update also introduces new target numbers for different low and zero-emissions vehicle types and charging and refuelling stations by 2030.

Type of policy: Regulatory

Implementing entity: Ministry of Transport (Government)

Period of implementation: 2015-2018 with an outlook to 2030

Implemented in scenario: WEM

Sector: Transport

Mitigation impact: This is a policy framework, therefore its mitigation effect is accounted under other measures.

Greenhouse gases covered: CO_2

b) Czech National Cycling Development Strategy for 2013-2020

In May 2013, the Czech government approved the strategic document "Czech National Cycling Development Strategy for 2013-2020" aiming to increase urban cycling modal share to 10% by 2020 and up to 25% by 2025 as well as increase the efficiency of building cycling infrastructure. Further, the Strategy calls for cooperation among the state, the regional level, and the local level, as well as the private and voluntary sectors.

The main global objective of the Cycling Strategy is to popularize bicycle to become equal-valuable natural and integral part of the transport system in cities.

The Strategy sets four specific goals:

- To secure the financing of the cycling and cycle-tourism infrastructure;
- To increase safety of cycling;
- To provide methodological support to the development of cycling in cities and to the project “Cycling Academy”;
- To implement the national product “Czechia Cycles”, the popularization of cycle-tourism in the Czech Republic.

The Strategy and the implementation of relevant measures to secure above mentioned goals are financed by the State Fund for Transport Infrastructure.

Type of policy: Economic

Implementing entity: State Fund of Transport Infrastructure (Government)

Period of implementation: 2013-2030

Implemented in scenario: WEM

Sector: Transport

Mitigation impact: The annual energy savings were estimated to be 585 TJ/year from 2020 with the annual budget of 150 million CZK.

Greenhouse gases covered: CO_2

<u>Legislative Instruments - EU Level</u>

a) EU Emissions Trading System

Under the EU Emission Trading System (EU ETS), all airlines operating in Europe, European and non-European alike, are required to monitor, report, and verify their emissions, and to surrender allowances against those emissions. The airlines receive tradeable allowances covering a certain level of emissions from their flights per year. As CO_2 emissions from aviation have been included in the wider EU ETS, the main carbon pricing instrument for aviation in Europe and the first large emissions trading scheme, this measure is described in detail as a cross-cutting measure in the relevant chapter.

b) ICAO Agreement

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 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.

The measure ‘ICAO Agreement’ is related to the agreement among ICAO’s 191 members in October 2016 to use an offsetting scheme called CORSIA. The scheme does not take effect until 2021 and will be voluntary until 2027. Under the agreement, the global aviation emissions target is a 50% reduction by 2050 relative to 2005.

Type of policy: Economic

Implementing entity: Ministry of Transport, Ministry of the Environment in relation to EU legislation (Government)

Period of implementation: Since 2021

Implemented in scenario: WAM

Mitigation impact: The emission reduction has been calculated by subtraction of supposed energy saving from air transport related total emissions. In the context of the Czech Republic, the total emission reduction of this measure is 5.9 kt. CO_2 eq. in 2035.

Sector: Transport

Greenhouse gas coverage: CO_2

c) EU Regulation 2019/1242 on setting CO_2 emission performance standards for new heavy-duty vehicles

The Regulation sets CO_2 emission performance requirements for new heavy-duty vehicles whereby the specific CO_2 emissions of the Union fleet of new heavy-duty vehicles shall be reduced compared to the reference CO_2 emissions as follows:

- for the reporting periods of the year 2025 onwards by 15%;
- for the reporting periods of the year 2030 onwards by 30%, unless decided otherwise pursuant to the review referred to in Article 15 in the Regulation.

The reference CO_2 emissions shall be based on the monitoring data reported pursuant to Regulation (EU) 2018/956 for the period from 1 July 2019 to 30 June 2020, excluding vocational vehicles.

Type of policy: Regulatory

Implementing entity: Ministry of Transport (Government)

Period of implementation: Since 2019

Implemented in scenario: Measure entered force only in 2019, therefore it is not implemented in scenarios.

Mitigation impact: As this is a framework measure, its mitigation impact is accounted under other measures.

Sector: Transport

Greenhouse gas coverage: CO_2

d) EU Regulation 2019/631 on setting CO_2 emission performance standards for new passenger cars and for new light commercial vehicles

The EU Regulation 2019/631 of the European Parliament and of the Council of April 2019 sets CO_2 emission performance standards for new passenger cars and for new light commercial vehicles, and repeals Regulations (EC) No 443/2009 and (EU) No 510/2011.

The Regulation sets cost-effective CO_2 emission reduction targets for new light-duty vehicles up to 2030 combined with a dedicated incentive mechanism to increase the share of zero/low-emission vehicles. The aim of the Regulation is to ensure that the EU automotive industry maintains its technological leadership also by strengthening its competitiveness and stimulating employment while ensuring a better functioning of the internal market and aiming to fulfil Paris Agreement on climate change's objective. Further, the Regulation will also reduce fuel consumption costs for consumers. The incentive mechanism to increase the share of zero/low-emission vehicles will in particular contribute to the reduction of air pollutants and in turn increase air quality with public health benefits.

From 1 January 2020, this Regulation sets an EU fleet-wide target of 95 g CO_2/km for the average emissions of new passenger cars and an EU fleet-wide target of 147 g CO_2/km for the average emissions of new light commercial vehicles registered in the Union. The Regulation will, until the end of the year 2024, be complemented by additional measures corresponding to a reduction of 10 g CO_2/km.

According to the Regulation, the following EU fleet-wide targets shall apply from January 1st, 2025:

a) For the average emissions of the new passenger car fleet, an EU fleet-wide target equal to a 15% reduction of the target in 2021;
b) For the average emissions of the new light commercial vehicles fleet, an EU fleet-wide target equal to a 15% reduction of the target in 2021.

From January 1st, 2030 the following EU fleet-wide targets shall apply:

a) For the average emissions of the new passenger car fleet, an EU fleet-wide target equal to a 37,5% reduction of the target in 2021;
b) For the average emissions of the new light commercial vehicles fleet, an EU fleet-wide target equal to a 31% reduction of the target in 2021.

From the beginning of 2025, a zero- and low-emission vehicles' benchmark equal to a 15% share of the respective fleets of new passenger cars and new light commercial vehicles shall apply (in accordance with points 6.3 of Parts A and B of Annex I, respectively). From 1 January 2030, the following zero- and low-emission vehicles' benchmarks shall apply, in accordance with points 6.3 of Parts A and B of Annex I, respectively:

a) A benchmark equal to a 35 % share of the fleet of new passenger cars;

b) A benchmark equal to a 30 % share of the fleet of new light commercial vehicles.

A new revision of the Regulation is currently being discussed as part of the Fit for 55 package

Compared to the CO_2 emission targets applicable in 2021, the emissions of new passenger cars registered in the EU would have to be 55% lower, and the emissions of new vans would have to be 50% lower. By 2035 new passenger cars and vans CO_2 emissions would have to be reduced by 100%, i.e. all new vehicles would have zero emissions.

Type of policy: Regulatory

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

Period of implementation: Since 2019

Implemented in scenario: Measure entered force only in 2019, therefore it is not implemented in scenarios.

Mitigation impact: As this is a framework measure, its mitigation impact is accounted under other measures.

Sector: Transport

Greenhouse gas coverage: CO_2

c) Directive 2009/33/EC on the promotion of clean and energy efficient road transport vehicles

The Directive 2009/33/EC has as its objectives the promoting and stimulating the market for clean and energy-efficient vehicles and improving the contribution of the transport sector to the environment, climate and energy policies of the Union. The Directive applies to procurement through contracts for the purchase, lease, rent or hire-purchase of road transport vehicles awarded by contracting authorities or contracting entities or, for instance, through public service contracts having as their subject matter the provision of passenger road transport services in excess of a further to be defined threshold. The Directive 2009/33/EC was amended by the Directive (EU) 2019/1161 of the European Parliament and of the Council of June 20 2019 and sets minimum procurement targets for the share of clean vehicles in the total number of road vehicles covered by contracts at Member State level, etc. The share for the Czech Republic at light-duty vehicles is set to be 29.7% from August 2nd 2021 to December 31st 2025 as well as from January 1st 2026 to December 31st 2030; different shares are set for buses and trucks. The transposition law is in the legislative process, with effect from August 2nd 2021 a government regulation was adopted.

Type of policy: Regulatory

Implementing entity: Ministry of Regional Development (Government)

Period of implementation: Since 2019

Implemented in scenario: Measure entered force only in 2019, therefore it is not implemented in scenarios

Mitigation impact: As this is a framework measure, its mitigation impact is accounted under other measures.

Sector: Transport

Greenhouse gas coverage: CO_2

d) Support of biofuels on the EU level

The quality of fuels used in transport is regulated by the Directive 2009/30/EC amending Directive 98/70/EC as regards the specification of petrol, diesel and gas-oil and introducing a mechanism to monitor and reduce greenhouse gas emissions. By the end of 2020, suppliers should gradually reduce life cycle greenhouse gas emissions by up to 10% per unit of energy from fuel and energy supplied, this reduction amounting to at least 6 % by the end of 2020 compared to the EU-average life cycle greenhouse gas emissions per unit of energy from fossil fuels in 2010, obtained through the use of biofuels, alternative fuels and reductions in flaring and venting at production sites.

Also, the EU Directive 2009/28/EC on the promotion of the use of energy from renewable sources was transposed by the Act on Air Protection 201/2012 Coll., which sets the minimal share of biofuels in gasoline and diesel. Further, on the national level, the Government Decree 351/2012 Coll. sets sustainability criteria of biofuels, and The Law on Consumption Tax 453/2016 Coll. levies biofuels with a lower tax rate. 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. From 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.

Type of policy: Regulatory

Implementing entity: Ministry of Industry and Trade, Ministry of Transport

Period of implementation: Since 2009

Implemented in scenario: WEM

Mitigation impact: The mitigation impact of biofuels was calculated using modification of emission factors per a unit of energy. The resulted emission factor is a weighted average of emission factors of fossil part and bio part, where weights correspond to the percentage of these components blending, and to plans to increase bio components blending to petrol and diesel. The total emission reduction of this measure is 198 kt CO_2 eq. in 2035.

Sector: Transport

Greenhouse gas coverage: CO_2

e) Support of electromobility on the EU level

Concerning the regulatory framework for the development of electromobility within the EU legislation, the Directive 2014/94/EU on the deployment of alternative fuels infrastructure as transposed to the national level via Act No. 152/2017 Coll. on fuels is relevant. This Act sets requirements on operators of charging stations and by registering them, the Ministry of Transport is able to publish lists of charging stations open to public.

Type of policy: Regulatory

Implementing entity: Ministry of Industry and Trade (Government)

Period of implementation: Since 2017

Implemented in scenario: WEM

Mitigation impact: Due to the nature of the framework measure, it is not possible to calculate its mitigation impact.

Sector: Transport

Greenhouse gas coverage: CO_2

<u>Legislative Instruments – national level</u>

a) Promotion of biofuels and fuels quality on national level

The quality of fuels used in transport is regulated by the Directive 2009/30/EC amending Directive 98/70/EC. The Fuel Quality Directive 2009/30/EC has been implemented into the Czech legislation (with regards to GHG emissions) via the amendment to the Act on Air Protection No. 201/2012 Coll., which sets minimal shares of biofuels in gasoline and diesel in accordance with the EU Directive.

The Directive 2009/30/EC requires that the emission intensity of transport fuels falls to 10% by the end of the year 2020, at least 6% compared to the average emission levels. The Government Decree 189/2018 Coll. sets sustainability criteria for biofuels and methodology for calculation greenhouse gas emission production from fuels. The Law on Consumption Tax 453/2016 Coll. Levies biofuels with a lower tax rate. The baseline shall be based on EU average level life cycle GHG emissions per unit of energy from fossil fuel products in 2010. Reducing GHG 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. GHG emissions from biofuels must be at least 50% lower than the level of GHG emissions of a fuel they replace. This figure rose to 60% from biofuels produced in installations starting operation from October 2015 until the end of the year 2020 and 65% for biofuels produced in installations starting operation from January 1st, 2021.

Type of policy: Regulatory

Implementing entity: Ministry of Industry and Trade (Government)

Period of implementation: since 2009

Implemented in scenario: WEM

Mitigation impact: The mitigation impact of biofuel was calculated by the modification of emission factors per a unit of energy. The resulted emission factor is 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 bio components blending to petrol and diesel. The total emission reduction of this measure is 198kt CO_2 by 2035.

Sector: Transport, Energy

Greenhouse gas coverage: CO_2

b) Economic and tax tools for road vehicles on national level

The objective of these tools is to promote the use of less polluting vehicles. This group of measures covers the following rules:

- Road Traffic Law 13/1997 and its amendments on the charging of the use of transport infrastructure for freight vehicles
- Road Tax Law 190/1993 and its amendments on road tax
- Excise Law 353/2003 supporting alternative fuels with lower CO_2 emissions (e.g. compressed natural gas – CNG, bio fuels – tax free)

Further, the Transport Policy of the Czech Republic for 2014-2020 with the Prospect of 2050 contains the 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
- To 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 fossil fuels
- To introduce speed limits on motorways and highways (higher speed causes more energy consumption and higher emissions).

Type of policy: Economic, Fiscal

Implementing entity: Ministry of Finance (Government)

Period of implementation: 2020-2030

Implemented in scenario: WAM

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

Sector: Transport

Greenhouse gas coverage: CO_2

c) Government Decree No. 173/2016 Coll. on determining binding criteria for awarding public contracts for the acquisition of road vehicles

The Decree reflects the Directive 2009/33/EC of the European Parliament and of the Council of April 2009 on the promotion of clean and energy-efficient road transport vehicles and determines binding award criteria of public contracts for the acquisition of road vehicles specifically in connection with the procurement of vehicles. The contracting authorities must define technical specification, including consumption, and emissions of CO_2, NOx, hydrocarbons, and other particles.

The possibility of contracting authorities to define their technical specifications is described in Act No. 134/2016 Coll. On Public Procurement which transposes the European Procurement Directive (Directive 2014/24/EU) as well as other Directives, such as the Directive 2014/25/EU on procurement by entities operating in the water, energy, transport and postal services sectors or the Directive 2014/23/EU on the award of concession contracts, into Czech law.

Type of policy: Regulatory

Implementing entity: Ministry of Regional Development (Government)

Period of implementation: Since 2016

Implemented in scenario: WEM

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

Sector: Transport

Greenhouse gas coverage: CO_2

Financial Schemes and Programmes

a) Operational Programme Transport

The current Operational Programme Transport 2014-2020 (hereinafter OPT2) follows the Operational Programme Transport 2007-2013 (hereinafter OPT1) and represents the most important source of financing for the construction of transport infrastructure in the Czech Republic in the programming period 2014-2020. OPT2 is one of the largest operational programmes taking about 17%, cca EUR 4.56 billion, of all funds for the Czech Republic from the European Structural and Investment Funds in the programming period. Its aim is to fulfil strategic investment needs and help solve key problems in the Czech transport sector.

The main objective is to provide support to sustainable transport and to remove barriers in key network infrastructures. Specifically, the aim is to finalize the backbone infrastructure and help regions access the Trans-European Transport Network (TEN-T), improve its quality and functionality, remove narrow areas in key infrastructure, and support sustainable mobility focusing on cities mainly. The OPT implements the transport strategy and other transport-related aspects of the National Development Plan. Taking into account lessons learnt from the OPT1, the OPT2 targets its support at four priority axis:

Priority Axis 1: Infrastructure for Railways and other modes of sustainable transport

Priority Axis 2: Road infrastructure within the TEN-T, public infrastructure for clean mobility and traffic management

Priority Axis 3: Road infrastructure excluding the TEN-T

Priority Axis 4: Technical assistance

With the OPT2, there are overall 79 subsidy programmes, applications for support to certain calls can be received until June 2023.

All projects implemented within individual Priority Axes favour mass transportation, aim to increase flow of road transportation and support ecological alternatives to road automobile transportation (water-borne and railway transportation) and thus have indirect positive effect on CO_2, NO_x and solid particle emissions.

Concerning clean mobility, the subsidy scheme The Development of Infrastructure for alternative fuels in road transport, funded by the OPT2, is further divided into four sub-programmes. These sub-programmes help fund the network development of fast-charging stations and charging stations (sub-programme 1), CNG filling stations (sub-programme 2), LNG filling stations (sub-programme 3), and hydrogen filling stations (sub-programme 4).

Type of policy: Economic

Implementing entity: State Fund of Transport Infrastructure (Government)

Period of implementation: 2007-2023

Implemented in scenario: WEM

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.

Sector: Transport

Greenhouse gas covered: CO_2

b) Support of public transport and modal shift from road transport

- **Increasing the attractiveness of public transport**

  - Further development of the integrated transport system

    The integrated transport system provides public transport in a certain region and includes several means of transport which do not compete within the system. Individual carriers can participate in this system and their transportation services are usually harmonized. The ITS systems in Prague, South Moravia and Ostrava belong to the most efficient systems in the Czech Republic. As this measure is valid on urban and regional level, it is impossible to quantify its mitigation impact.

  - Increasing passengers' comfort

    The comfort of passengers is increased via different measures including air-conditioning, cleanliness and by the design of the internal environment of the means of transport itself. Travelling is also made more comfortable for disabled citizens or mothers with prams, for instance. Due to the character of this measure, it is not possible to determinate its contribution to GHG emission reduction.

  - Strengthening preferences for public transport vehicles

    In order to enable public transport vehicles to drive faster, extra lanes for buses or trolleybuses are designed. Also, urban public transport receives priority on intersections with light control systems.

  - Introducing the "Park and Ride" system

    Efforts to improve multi-modal passenger transport by "Park and Ride" (P&R) are made to encourage people to leave their cars at the outskirts of Prague and instead take public transport to the centre. In Prague, for instance, this system combines the increasing rates of parking fees in locations where quieter environments are preferred (so called “blue zones”) with cheap fees at guarded parking places outside of the city centre.

- **Creating systems of combined freight transport**

The use of multimodal transport systems is preferred to reduce the performance of road transport in favour of those modes of transport that have less impact on the environment. Relevant measures, as described in the Transport Policy of the Czech Republic for 2014-2020 with the Prospect of 2050, seek to find effective and sustainable logistics solutions using the principle of co-modality with the view to support multimodal nature of transport, optimize the capacity of transport infrastructure and use of energy and make logistics services available to small and middle-sized businesses in industry, trade and agriculture. Further, competitive multimodal transport chains for companies, using the railway and possibly waterborne transport with the objective to improve capacity utilization of the means of transport and reducing empty rides, reduction of heavy road transport, better cooperation and coordination among companies in the area of transport, support of small and middle-sized enterprises, and reduction of negative impacts on the environment, public health and transport safety.

Also, 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).

In total, all fourteen regional authorities in the Czech Republic make effort to develop integrated transport systems (ITS) and are the implementing authorities of this measure. In some regions (Southern and Northern Moravian, Olomouc, Middle Bohemian) these systems already exist, in other regions they are being prepared**.**

Type of policy: Regulatory

Implementing entity: 14 regions/regional authorities

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. Within the projections this measures is calculated until 2035.

Implemented in scenario: WEM

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

Sector: Transport

Greenhouse gas coverage: CO_2

- **Road toll**

Since 2010, certain vehicles are subject to toll payment including vehicles over 3.5 tons. The charge level is derived from the type of vehicle, number of axles, and the time when the road is used.

Type of policy: Fiscal

Implementing entity: Ministry of Transport (Government)

Period of implementation: 2020-2035

Implemented in scenario: WAM

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 thus calculated to be 161.9 kt. CO_2 eq. by 2035.

Sector: Transport

Greenhouse gas coverage: CO_2

c) Clean Mobility

As mentioned above, there are several subsidy schemes funding clean mobility.

The Integrated Regional Development Programme helps fund the purchase of buses using alternative fuels. So far, there have been three calls: “Low-carbon and Zero-emission vehicles” (2016-2017, allocation: EUR 100 million, 211 vehicles were bought for public transportation), “Sustainable Transportation” (2017-2019, allocation: EUR 300 million, by the end of 2019 around 190 vehicles were bought for public transportation), and “Low-emission and Zero-emission vehicles for coal-mining regions, allocation: CZK 1 839 877 615 = EUR 71 148 067).

The Operational Programme Enterprise and Innovation for Competitiveness helps fund the purchase of electric cars for entrepreneurs. Within the programme to support low-emission technologies and via the sub-programme Electromobility, four calls were announced.

1st call (spring 2016) – allocation: CZK 80 million

2nd call (2017) – allocation: CZK 150 million

3rd call (2018) – allocation: CZK 60 million

4th call (2019) – allocation: CZK 200 million

In total (excluding the 4th call), 536 electronic cars were bought and 255 charging stations were built.

The **National Programme of the Ministry of Environment of the Czech Republic** helps purchase municipalities vehicles that use alternative fuels. The Programme is directed at applicants that are either regions or municipalities, region-owned or municipality-owned market economy operators, or contributory organisations set up by regions/municipalities and state-owned contributory organisations. So far, CZK 100 million was allocated to the first two calls (2016-2017), the third call has been launched in autumn 2018.

Further, e-vehicles are exempted from paying road tax and, in the context of adopting the NAP CM, e-vehicles are also exempted from paying motorway tolls. Vehicles using other alternative fuels pay less than conventional vehicles for motorway tolls, other discussions on further exemptions are undergoing.

Type of policy: Regulatory, Economic

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

Period of implementation: As described above for individual programmes.

Implemented in scenario: WEM

Mitigation Impact: The Programmes being in their rather initial phases, the mitigation impact of the programmes combined is not possible to calculate.

Sector: Transport

Greenhouse gas coverage: CO_2

4.4 Mechanism according to Art. 6, 12 and 17 of the Kyoto Protocol

The Czech Government approved the Framework agreement on cooperation in implementing projects seeking reduction of greenhouse gas emissions with the International Bank for Reconstruction and Development (IBRD) and other investor countries by its Resolution No. 648 dated 30. 6. 2003. In 2008 the Czech Republic approved guidelines for participation of private entities from the Czech Republic in project activities implemented according to mechanisms under Article 6 and 12 of the Kyoto Protocol. The Czech Republic authorized subjects accredited for verification under the EU Emission Trading Scheme (EU ETS) to undertake verification of Joint Implementation project activities according to the mechanism under the Article 6 of the Kyoto protocol.

During the first commitment period of the Protocol (2008–2012) 85 Joint Implementation (JI) projects were approved. Implementation of all JI projects during 2002–2012 generated approximately 7.446 million AAUs, and from this amount the issued ERUs reached 4.413 million. Act No. 383/2012 Coll., on conditions of trading with greenhouse gas emission allowances allows use of free AAUs to support project according to Art. 6 of the Protocol.

In April 2009 the Czech Republic started new subsidy Programme „Green Savings“ which was implemented as a Green Investment Scheme (GIS) activity and founded by International Emission Trading according to Article 17 of the Kyoto Protocol. Programme was focused on energy savings and utilization of renewable energy sources in residential sector. Until 2012 the Czech Republic has signed a number of bilateral agreements on selling AAUs (AAU Purchase Agreements) with Japan, Mitsui & Co., Ltd. Austria, Spain and IBRD.

The Czech Republic does not intend to use Kyoto mechanims for the fullfilment the quantified emission limitation or reduction commitment during the second commitment period of the Kyoto Protocol.

5 PROJECTIONS AND TOTAL EFFECT OF POLICIES AND MEASURES

5.1 Projections

5.1.1 Emission projection scenarios and division to sectors

The following projections have been prepared in line with methodological guidelines for projection compilation[18] and in line with Regulation (EU) No 525/2013. Projections contain two scenarios:

- With existing measures (WEM) - with measures implemented and effective as of the date when preparation of projections began (July 2020);
- With additional measures (WAM) - with measures which are going to be implemented in near future or which are planned to be implemented in future.

The table below provides overview of projection results. Reported data of the greenhouse gases emissions in the tables of National communication have been updated based on the last inventory submission in 2022, with 2020 as the last reported year. Projected data of the greenhouse gases emissions are based on the projections introduced in 2021. Therefore 2020 values can differ for reported and projected emissions.

The differences for 2020 between projected emissions and reported emissions are caused by the fact, that while preparing the projections of emissions for the projections reporting in 2021, all input data were based on projected data which were not expecting so huge impact of the COVID-19 pandemic. Even though some impact was foreseen, the uncertainties during the preparation were quite significant. Due to the fact, that the projections input data were actually prepared in middle 2020, the effect of the COVID-19 pandemic was unsure, and is actually resulting in the difference between the projected data and reported data in the inventory submitted in 2022. Contrary, the data for the greenhouse gas inventory submitted in April 2022 was already prepared based on the real statistical data for 2020, which is actually reflecting the real situation in 2020.

All specific Policies and Measures (PaMs) included in WEM and WAM scenarios are presented for each sector in respective chapters.

Table 5.1: Reported and projected emissions of GHG – WEM and WAM (including LULUCF) [Mt CO_2 eq., % reduction in comparison with 1990]

[Mt CO_2eq.]	Reported emissions			Projected emissions						Difference [%]			
	1990	2005	2020	2020	2025	2030	2035	2040	2050	1990–2020	1990–2030	1990–2040	1990–2050
WEM	188.02	139.76	125.56	140.17	112.77	105.46	91.65	75.26	74.15	-25.45	-43.91	-59.97	-60.56
WAM	188.02	139.76	126.56	139.86	103.59	82.60	70.57	56.37	54.88	-25.62	-56.07	-70.02	-70.81

Source: CHMI

The projections of greenhouse gas emissions are prepared for the following sectors (division to the sectors is in line with IPCC 2006 Guidelines (IPCC 2006)):

[18] UNFCCC Reporting Guidelines on National Communication, FCCC/CP/1999/7, part II

1. Energy (Sector 1) - greenhouse gas emissions from combustion processes and fugitive emissions
2. Industrial Processes and Product Use (IPPU) (Sector 2) - greenhouse gas emissions resulting from industrial activities and not from fuel combustions used to supply energy for carrying out these activities
3. Agriculture (Sector 3)
4. Land use, Land Use Change and Forestry (LULUCF) (Sector 4)
5. Waste (Sector 5)

Total greenhouse gas emissions are calculated as a sum of CO_2, N_2O, CH_4, HFCs, PCFs, SF_6 and NF_3 emissions expressed in CO_2 eq. Methodological operations and modelling tools used for projections of greenhouse gases are described in the text below for every sector.

5.1.2 Energy (Sector 1)

Projections of greenhouse gas emissions from Energy include the following activities:

CO_2 emissions

- Fuel combustion in fuel conversion processes (public and industrial energy sector),
- Fuel combustion in final consumption (industrial processes, transportation, households, agriculture and sector of public and commercial services),
- Fuel refinement processes (refineries, coal treatment and coking),
- Desulfurization processes using lime.

CH_4 emissions

- Mining and post-mining treatment of coal,
- Mining, storage, transit and distribution of natural gas,
- Mining, storage, transportation and refining of oil.

N_2O emissions

- Fuel combustion (in stationary or mobile sources).

Projections of greenhouse gas (GHG) emissions from sector 1. Energy were 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 were prepared using a data-driven model structure applying expert judgement.
- Projections of emissions from category 1.A.3 – projections were prepared by using data from COPERT.

Data used as input data includes data for electricity and heat production provided by the Ministry of Industry and Trade (MIT), who collects data regarding future plans of energy and industrial companies, such as constructions of new sources or shut-downs, technical details, life expectancy, investment, operating costs. MIT and Czech electricity and gas market operator (Operátor trhu s elektřinou, a.s.) (OTE) provide information about the development of energy production and consumption. The input data also correspond to the State Energy Policy (MIT, 2015).

Table 5.2: Final energy consumption

Energy source [PJ]	2010	2015	2020	2025	2030	2035	2040	2045	2050
Coal	83.1	70.5	59.1	45.6	37.1	29.7	27.6	25.0	23.6
Manufactured gases	14.1	13.0	12.1	11.8	11.2	11.1	11.0	10.9	10.9
Oil and petroleum products	262.4	268.8	269.0	270.9	268.2	266.1	259.9	248.8	231.0
Natural gas	254.9	210.4	224.2	217.6	206.0	205.2	203.9	201.7	199.6
Renewables and biofuels	94.1	114.2	124.0	138.6	153.1	154.5	148.8	142.3	134.7
Non-renewable waste	6.7	9.3	9.8	9.6	9.3	9.3	9.2	9.1	9.1
Derived heat	105.7	86.5	89.3	85.5	80.9	78.0	75.0	71.4	68.1
Electricity	195.2	196.7	213.8	219.3	223.8	229.1	236.7	243.4	248.5
TOTAL	**1096.3**	**969.4**	**1 002.0**	**999.4**	**990.3**	**983.6**	**972.6**	**953.3**	**926.0**

Source: MIT(2015)

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

Table 5.3: Final energy consumption of households

Energy source [PJ]	2010	2015	2020	2025	2030	2035	2040	2045	2050
Coal	44.2	39.9	30.0	23.7	17.3	10.7	9.8	8.8	7.9
Oil and petroleum products	1.0	1.9	1.8	1.8	1.7	1.7	1.5	1.4	1.3
Natural gas	99.7	74.9	83.3	72.9	61.7	59.3	57.2	55.2	53.0
Renewables and biofuels	63.5	74.0	75.2	84.5	93.7	94.3	88.0	81.2	74.1
Derived heat	51.8	42.5	43.1	41.7	40.4	39.0	37.6	36.1	34.5
Electricity	54.1	51.8	55.2	57.0	59.0	61.2	63.7	65.5	66.9
TOTAL	314.3	285.0	288.5	281.6	273.9	266.3	257.9	248.3	237.7

Source:MIT (2015)

Table 5.4: Final energy consumption of commercial sector

Energy source [PJ]	2010	2015	2020	2025	2030	2035	2040	2045	2050
Coal	1.7	1.1	1.0	0.6	0.3	0.0	0.0	0.0	0.0
Oil and petroleum products	0.8	1.1	1.0	0.9	0.8	0.6	0.4	0.2	0.0
Natural gas	54.0	45.1	45.5	42.3	38.9	35.6	32.4	29.5	27.2
Renewables and biofuels	2.1	2.6	2.6	2.7	2.8	2.9	2.9	3.0	3.0
Derived heat	22.7	18.4	18.5	17.8	17.0	16.3	15.5	14.8	14.0
Electricity	53.5	53.6	57.7	57.0	55.8	54.5	52.8	51.3	50.4
Other	1.1	1.4	1.2	1.2	1.2	1.2	1.2	1.2	1.2
TOTAL	**135.8**	**123.2**	**126.4**	**121.4**	**115.6**	**109.9**	**104.1**	**98.7**	**94.6**

Source: MIT (2015)

Table 5.5: Structure of charge for electricity and district heat generation

Charge for electricity and heat [PJ]	2010	2015	2020	2025	2030	2035	2040	2045	2050
Coal	580.3	485.1	471.6	364.2	361.7	289.8	147.9	141.9	139.2
Manufactured gases	30.7	28.5	30.5	30.6	30.4	30.0	13.1	6.9	6.9
Oil and petroleum products	3.9	2.1	1.4	1.4	1.4	1.4	1.3	1.3	1.3
Natural gas	50.1	48.3	56.7	57.4	50.9	46.8	101.7	116.2	114.9
Renewables and biofuels	36.9	64.9	67.0	76.5	89.2	100.8	110.6	113.2	115.9
Industrial waste	0.5	0.8	0.7	0.7	0.7	0.7	0.7	0.7	0.6
Municipal waste	1.2	1.6	1.8	4.9	5.8	5.8	5.8	5.8	5.8
Nuclear power plants	305.6	292.6	339.3	339.5	339.8	394.7	464.0	464.3	464.6
Derived heat	0.3	0.4	1.0	1.0	1.0	1.0	1.0	0.9	0.9
Electricity	2.9	6.0	5.7	5.7	5.7	5.7	5.7	5.7	5.8
TOTAL	**1012.3**	**930.2**	**975.8**	**881.9**	**886.5**	**876.5**	**851.8**	**856.9**	**855.8**

Source: MIT (2015)

Projections from category 1A3 Transport were 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 (MoT 2013). Also, non-road transport forecasts were not changed.

Projection results – WEM and WAM scenario

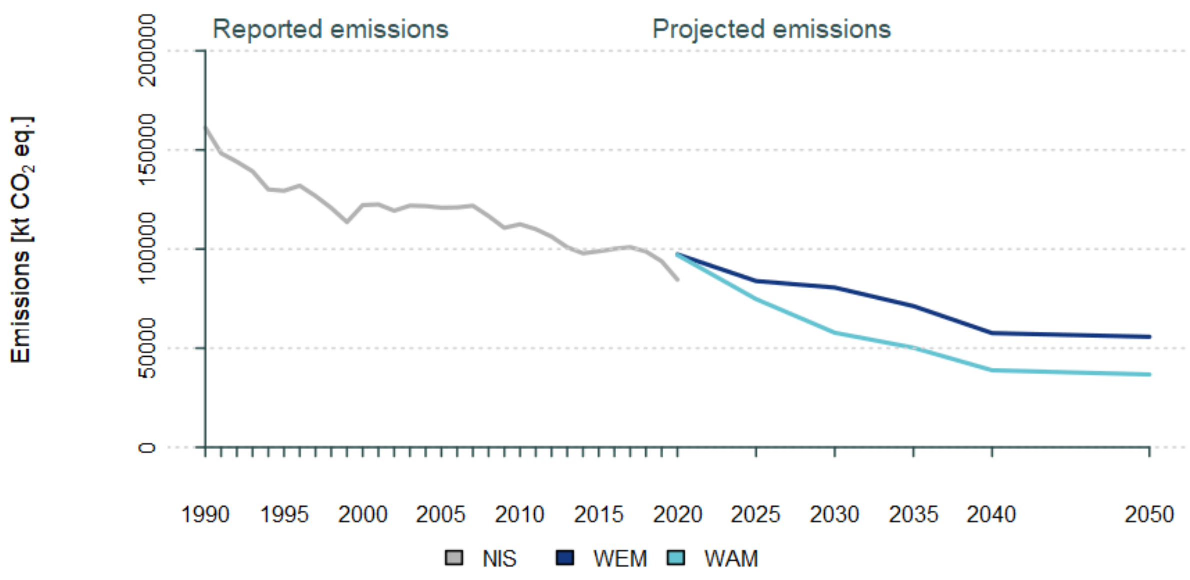
According to the projections of GHG emissions in 1. Energy sector it is expected that emissions are going to decrease for both scenarios. Decrease of emissions is more visible for WAM scenario which includes additional measures for category 1.A.1 Energy industries, 1.A.2 Manufacturing Industries and construction, 1.A.3 Transport and 1.A.4 Other sectors. For 2050, the difference between WEM and WAM scenario is calculated as 19.01 Mt CO_2 eq.

Table 5.6: Projections of total greenhouse gas emissions from the Energy sector – WEM and WAM scenarios [Mt CO_2 eq., respectively % reduction in comparison with 1990]

[Mt CO_2eq.]	Reported emissions			Projected emissions						Difference [%]			
	1990	2005	2020	2020	2025	2030	2035	2040	2050	1990–2020	1990–2030	1990–2040	1990–2050
WEM	161.18	120.87	84.58	97.29	83.85	80.56	71.21	57.58	55.72	-39.64	-50.02	-64.28	-65.43
WAM	161.18	120.87	84.58	96.97	74.74	57.77	50.20	38.83	36.71	-39.84	-64.16	-75.91	-77.22

Source: CHMI

Figure 5.1: Reported and projected emissions of GHG in 1. Energy (including Transport) – WEM, WAM scenario



Source: CHMI

<u>WEM scenario</u>

The 1. 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 1. Energy sector during projected period. It is expected that in 2050 CO_2 emissions will decrease by 64%, CH_4 by 88% and N_2O by 50% compared to 1990 emissions.

Table 5.7: Policies and Measures included in projections in Energy - WEM scenario

PaM title	Sector	Period of implementation	Gas affected
EU ETS (cross-cutting)	1.A.1., 1.A.2.	2005–2040	CO_2, N_2O, PFCs
ICAO	1.A.3.	2000–2035	CO_2
Air protection Act (cross-cutting)	1	2002–2040	CO_2, CH_4, N_2O
The Climate Protection Policy of the Czech Republic (cross-cutting)	1	2017–2030	CO_2, CH_4, N_2O, SF_6, NF_3
Eco-design	1.A.	2007–2035	CO_2
Energy Management Act	1.A.	2000–2035	CO_2
National Energy Efficiency Action Plan (NEEAP)	1	2008–2020	CO_2
State programme on promotion of energy savings (EFEKT 2)	1.A.	2017–2035	CO_2
Operational Programme Enterprise and Innovation for Competitiveness	1.A.2., 1.A.4.a.,1.A.4.c.	2014–2020	CO_2
Implementation of the Directive on the energy performance of building (2010/31/EU)	1.A.1., 1.A.2.,1.A.4.	2007–2035	CO_2
ENERG Programme	1.A.2., 1.A.4.	2017–2033	CO_2
Operational Programme Prague Growth Pole	1.A.3., 1.A.4.a.	2014–2020	CO_2

PaM title	Sector	Period of implementation	Gas affected
Energy Act	1.A.1.	2000–2035	CO_2
National Renewable Energy Action Plan (NREAP)	1.A.1.	2010–2020	CO_2
Preferential feed-in tariffs for electricity produced from renewable energy sources	1.A.1.a.	2004–2035	CO_2
EU regulation on CO_2 from light-commercial vehicles (vans)	1.A.3.	2000–2035	CO_2
EU regulation on CO_2 from passenger cars	1.A.3.	2000–2035	CO_2
Support of biofuels	1.A.3.	2000–2030	CO_2
Support of public transport and modal shift from road transport	1.A.3.	There is no uniform period. Each region has its own development plan. Plans are partly coordinated by the Ministry for Regional Development.	CO_2
Operational Program Transport	1.A.3.	2007–2020	CO_2
National Strategy of Cycling Transport Development	1.A.3.	2015–2020	CO_2
Operational Programme Environment 2014–2020	1.A.4.a., 1.A.4.b.	2014–2020	CO_2
Programme PANEL/NEW PANEL/PANEL 2013+	1.A.4.b.	2001–2020	CO_2
New Green Savings Programme 2014–2020	1.A.4.b.	2014–2020	CO_2
Integrated Regional Operating Programme	1.A.4.a., 1.A.4.b.	2014–2020	CO_2
Directive 2012/27/EU on energy efficiency (Article 5)	1.A.4.a.	2011–2030	CO_2

Source: MoE

Table 5.8: Breakdown of reported and projected emissions of GHG by gases in Energy - WEM scenario

[Mt CO_2eq.]	Reported emissions			Projected emissions						Difference [%]			
	1990	**2005**	**2020**	**2020**	**2025**	**2030**	**2035**	**2040**	**2050**	**1990–2020**	**1990–2030**	**1990–2040**	**1990–2050**
CO_2	147.11	113.03	80.69	92.66	80.59	77.42	68.40	55.23	53.68	-37.01	-47.38	-62.46	-63.51
CH_4	13.28	7.18	3.27	4.00	2.71	2.61	2.32	1.92	1.64	-69.85	-80.38	-85.52	-87.68
N_2O	0.79	0.66	0.62	0.62	0.56	0.54	0.49	0.42	0.40	-21.27	-31.97	-46.25	-49.65
Total	**161.18**	**120.87**	**84.58**	**97.29**	**83.85**	**80.56**	**71.21**	**57.58**	**55.72**	**-39.64**	**-50.02**	**-64.28**	**-65.43**

Source: CHMI

Table 5.9: Breakdown of reported and projected emissions of GHG by categories in Energy - WEM scenario

[Mt CO_2eq.]	Reported emissions			Projected emissions						Difference [%]			
	1990	**2005**	**2020**	**2020**	**2025**	**2030**	**2035**	**2040**	**2050**	**1990–2020**	**1990–2030**	**1990–2040**	**1990–2050**
1. Energy	**161.18**	**120.87**	**84.58**	**97.29**	**83.85**	**80.56**	**71.21**	**57.58**	**55.72**	**-39.64**	**-50.02**	**-64.28**	**-65.43**
A. Fuel combustion (sectoral approach)	**149.32**	**114.20**	**82.27**	**94.07**	**81.95**	**78.74**	**69.65**	**56.42**	**54.80**	**-37.00**	**-47.27**	**-62.21**	**-63.30**

1. Energy industries	56.86	63.17	41.60	53.17	44.78	44.04	35.96	23.48	23.17	-6.49	-22.54	-58.70	-59.25
2. Manufacturing industries and construction	47.11	18.85	10.24	9.98	9.78	9.58	9.38	9.18	8.78	-78.83	-79.67	-80.52	-81.36
3. Transport	11.35	17.37	17.79	18.21	16.20	15.37	15.47	15.26	15.07	60.47	35.44	34.48	32.80
4. Other sectors	33.81	14.55	12.31	12.41	10.90	9.46	8.55	8.21	7.49	-63.29	-72.02	-75.72	-77.84
5. Other	0.19	0.27	0.32	0.31	0.30	0.29	0.29	0.29	0.29	59.90	50.60	50.24	49.51
B. Fugitive emissions from fuels	**11.86**	**6.66**	**2.31**	**3.22**	**1.90**	**1.82**	**1.56**	**1.16**	**0.92**	**-72.88**	**-84.68**	**-90.22**	**-92.25**
1. Solid fuels	10.78	5.76	1.70	2.60	1.33	1.31	1.08	0.70	0.51	-75.88	-87.89	-93.49	-95.24
2. Oil and natural gas and other emissions from energy production	1.08	0.90	0.61	0.62	0.57	0.51	0.49	0.46	0.41	-42.99	-52.66	-57.62	-62.48
C. CO_2 transport and storage	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**

Source: CHMI

WAM scenario

Additional policies and measures (PaM) are focusing on reduction of CO_2. Modernisation fund is focusing on reduction on CO_2 and CH_4. According to the projected WAM scenario, emissions from Energy should have a strong decrease by 2050 compared to 2020 (Tabs 5.11, 5.12).

Table 5.10: Additional Policies and Measures included in projections in Energy - WAM scenario

PaM title	Sector	Period of implementation	Gas affected
Modernisation fund	1.A.1.,1.A.2.,1.A.3.,1.A.4.	2021–2030	CO_2, CH_4
Energy efficiency measures in industry sector in the period 2021–2030	1.A.1., 1.A.2.	2021–2030	CO_2
Soft energy efficiency measures in the period 2021 –2030	1.A.1., 1.A.2.,1.A.4.a.,1.A.4.b.	2021–2030	CO_2
Economic and tax tools for road vehicles	1.A.3.	2020–2030	CO_2
Road toll	1.A.3.	2020–2035	CO_2
Further decrease of CO_2emissions in 2025 and 2030	1.A.3.	2020–2030	CO_2
Energy efficiency measures in residential sector in the period 2021–2030	1.A.4.b.	2021–2030	CO_2
Energy efficiency measures in commercial and institutional sector in the period 2021–2030	1.A.4.a.	2021–2030	CO_2

Source: MoE

The GHG emissions from transport are expected to decline in both scenarios WEM and WAM from 2020. 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. The main efficiency has the application of CO_2 regulation of cars and vans and also the support of biofuels.

Table 5.11: Breakdown of reported and projected emissions of GHG by gases in Energy - WAM scenario

[Mt CO_2eq.]	Reported emissions			Projected emissions						Difference [%]			
	1990	**2005**	**2020**	**2020**	**2025**	**2030**	**2035**	**2040**	**2050**	**1990–2020**	**1990–2030**	**1990–2040**	**1990–2050**
CO_2	147.11	113.03	80.69	92.35	71.49	54.66	47.43	36.51	34.71	-37.22	-62.85	-75.18	-76.40
CH_4	13.28	7.18	3.27	4.00	2.71	2.61	2.32	1.92	1.64	-69.85	-80.38	-85.52	-87.68
N_2O	0.79	0.66	0.62	0.62	0.54	0.51	0.46	0.39	0.36	-21.68	-36.00	-50.65	-53.99
Total	**161.18**	**120.87**	**84.58**	**96.97**	**74.74**	**57.77**	**50.20**	**38.83**	**36.71**	**-39.84**	**-64.16**	**-75.91**	**-77.22**

Source: CHMI

Table 5.12: Breakdown of reported and projected emissions of GHG by categories in Energy - WAM scenario

[Mt CO_2 eq.]	Reported emissions			Projected emissions						Difference [%]			
	1990	**2005**	**2020**	**2020**	**2025**	**2030**	**2035**	**2040**	**2050**	**1990–2020**	**1990–2030**	**1990–2040**	**1990–2050**
1. Energy	**161.18**	**120.87**	**84.58**	**96.97**	**74.74**	**57.77**	**50.20**	**38.83**	**36.71**	**-39.84**	**-64.16**	**-75.91**	**-77.22**
A. Fuel combustion (sectoral approach)	**149.32**	**114.20**	**82.27**	**93.76**	**72.84**	**55.95**	**48.64**	**37.67**	**35.79**	**-37.21**	**-62.53**	**-74.77**	**-76.03**
1. Energy industries	56.86	63.17	41.60	53.17	41.90	33.34	27.38	17.14	16.82	-6.49	-41.35	-69.86	-70.41
2. Manufacturing industries and construction	47.11	18.85	10.24	9.98	8.42	5.88	5.73	5.63	5.23	-78.83	-87.51	-88.05	-88.90
3. Transport	11.35	17.37	17.79	17.89	13.41	10.03	9.59	9.11	8.67	57.69	-11.61	-19.71	-23.60
4. Other sectors	33.81	14.55	12.31	12.41	8.81	6.40	5.64	5.50	4.78	-63.29	-81.06	-83.73	-85.86
5. Other	0.19	0.27	0.32	0.31	0.30	0.29	0.29	0.29	0.29	59.90	50.60	50.24	49.51
B. Fugitive emissions from fuels	**11.86**	**6.66**	**2.31**	**3.22**	**1.90**	**1.82**	**1.56**	**1.16**	**0.92**	**-72.88**	**-84.68**	**-90.22**	**-92.25**
1. Solid fuels	10.78	5.76	1.70	**2.60**	**1.33**	**1.31**	**1.08**	**0.70**	**0.51**	**-75.88**	**-87.89**	**-93.49**	**-95.24**
2. Oil and natural gas and other emissions from energy production	1.08	0.90	0.61	0.62	0.57	0.51	0.49	0.46	0.41	-42.99	-52.66	-57.62	-62.48
C. CO_2transport and storage	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**

Source: CHMI

<u>International aviation</u>

Projected value of the fuel sold to aircraft was not calculated by our team, but it was added according to the EEA report. For all the projection years and both WEM and WAM scenarios the total of GHG emissions is 1248.26 kt CO_2 eq.

Sensitivity analysis

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

Concrete example of the sensitivity analysis for category 1.A.1.a Public electricity and heat production is depicted in Tab.5.14.

Table 5.13: Sensitivity analysis of 1.A.1.a Public electricity and heat production on input activity data (WEM scenario)

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

Source: CHMI

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

Difference between previously and currently reported projections

There are some significant changes in projections of GHG emissions from the 1. Energy sector compared to the previous projections. These changes are mentioned in the section 5.3 Methodology (Tab 5.49). The biggest change is that we stopped using model MESSAGE and used data-driven model structure instead.

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

5.1.3 Industrial Processes and Product Use (Sector 2)

Sector IPPU includes emissions from technological processes and not from fuel combustions used to supply energy for carrying out these processes. Projections of greenhouse gas emissions include the following activities:

CO_2 emissions

- Mineral industry,
- Chemical industry,
- Metal industry,

- Non-energy products from fuels and solvent use.

CH_4 emissions

- Chemical industry,
- Metal industry.

N_2O emissions

- Chemical industry,
- Other product manufacture and use.

HFCs emissions

- Product uses as substitutes for ODS.

PFCs emissions

- Electronics industry,
- Product uses as substitutes for ODS.

SF_6 emissions

- Electronics industry,
- Other product manufacture and use.

NF_3 emissions

- Electronics industry.

The projections of GHG emissions in 2. IPPU are based on data and methodology used for inventory emission estimates reported in National Inventory Report (NIR) (CHMI, 2020). The projections are estimated separately for each subcategory under 2. IPPU sector and also for each GHG. In the Czech Republic, there is no additional measure for 2. IPPU sector and thus only scenario With existing measures (WEM) is calculated.

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,2020) for 2019-2050. The activity data for 2.C.2 - 2.C.7 were projected using statistical methods (see Table 5.14) by 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 are no official forecasts of the fluorinated GHG (F-gases) consumption for 2.E Electronics industry, 2.F Substitutes for ozone depleting substances and 2.G Other product manufacture and use. Thus, the activity data is based on expert judgement at CHMI, strictly following Regulation No 517/2014, Directive 2006/40/EC and Kigali Amendment of the Montreal Protocol. Correlation of F-gases consumption with GDP or number of inhabitants is also investigated for better accuracy of activity data projections.

Projection results – WEM scenario

The WEM scenario includes policies and measures which affect consumption of F-gases.

Table 5.14: Policies and Measures included in projections in IPPU - WEM scenario

PaM title	**Period of implementation**	**Gas affected**
EU ETS (cross-cutting)	2005–2040	CO_2, N_2O, PFCs
Air protection act (Emission limits in Air protection act (201/2012 Coll.)	2003–2035	CO_2
The Climate Protection Policy of the Czech Republic (cross-cutting)	2017–2030	CO_2, CH_4, N_2O, SF_6, NF_3
Implementation of Regulation (EU) No 517/2014 on Fluorinated greenhouse gases	2015–2035	HFCs
Kigali Amendment to Montreal Protocol	2019–2036	HFCs

Source: MoE

According to WEM scenario, total emissions from 2. IPPU will be stagnant in next few years and then slightly decreasing. It is not expected that the production capacity for main products, such as lime, cement, ammonia, iron and steel is going to decrease rapidly in the Czech Republic. The expectation is rather that the decrease of GHG emissions until 2050 will be very slight, mainly influenced by the ban on F-gases.

Table 5.15: Reported and projected emissions of GHG in 2. IPPU – WEM scenario

[Mt CO_2eq.]	**Reported emissions**			**Projected emissions**						**Difference [%]**			
	1990	**2005**	**2020**	**2020**	**2025**	**2030**	**2035**	**2040**	**2050**	**1990–2020**	**1990–2030**	**1990–2040**	**1990–2050**
WEM	17.25	15.15	15.23	16.16	14.67	13.86	13.18	12.85	12.77	-6.32	-19.65	-25.51	-25.97

Source: CHMI

Decrease of HFCs, PFCs, NF_3 emissions compared to 1990 cannot be calculated because at that time these F-gases were not used in the Czech Republic and thus emissions are reported as not occurring (NO). Therefore, the base year for F-gases is 1995 (CHMI, 2020) (IPCC, 2006). It is expected that HFCs emissions will start to decrease around 2020. Compared to 2020, HFCs emissions should be 85% lower in 2050. The decrease of F-gases emissions will not be as rapid as one could expect because emissions are released during the equipment’s lifetime, which in some cases can be more than a decade. SF_6 and NF_3 are used by semiconductor manufacturers and SF_6 also as and insulation gas in switchgears. Emissions of SF_6 will start to decline unlike emissions of NF_3, which is expected to be more commonly used in near future. PFCs are not used anymore in the Czech Republic but formation of CF_4 as a byproduct during etching and cleaning in semiconductor industry is taken into account and thus emissions will be still occurring.

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

Table 5.16: Breakdown of reported and projected emissions of GHG by gases in 2. IPPU - WEM scenario

[Mt CO_2eq.]	Reported emissions			Projected emissions						Difference [%]			
	1990	2005	2020	2020	2025	2030	2035	2040	2050	1990–2020	1990–2030	1990–2040	1990–2050
CO_2	15.79	12.34	10.72	11.89	11.64	11.63	11.54	11.49	11.42	-24.68	-26.33	-27.21	-27.66
CH_4	0.05	0.06	0.05	0.07	0.07	0.07	0.07	0.07	0.07	36.75	36.75	36.75	36.75
N_2O	1.33	1.17	0.37	0.43	0.44	0.44	0.44	0.45	0.65	-67.63	-66.88	-66.13	-51.07
HFCs	NO	1.45	4.02	3.7	2.46	1.66	1.08	0.79	0.59	NA	NA	NA	NA
PFCs	NO	0.01	0.00	0	0	0	0	0	0	NA	NA	NA	NA
SF_6	0.08	0.11	0.07	0.07	0.06	0.05	0.04	0.04	0.03	-16.90	-40.65	-52.52	-64.39
NF_3	NO	NO	0.00	0	0	0.01	0.01	0.01	0.01	NA	NA	NA	NA
Total	**17.25**	**15.15**	**15.23**	**16.16**	**14.67**	**13.86**	**13.18**	**12.85**	**12.77**	**-6.32**	**-19.65**	**-25.51**	**-25.97**

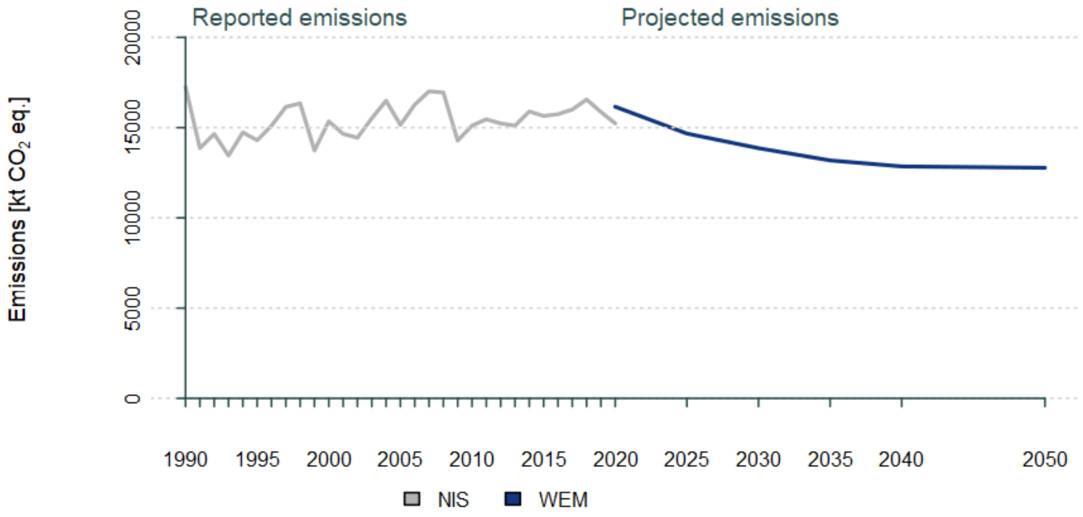
Source: CHMI

Table 5.17: Breakdown of reported and projected emissions of GHG by categories in 2. IPPU - WEM scenario

[Mt CO_2eq.]	Reported emissions			Projected emissions						Difference [%]			
	1990	2005	2020	2020	2025	2030	2035	2040	2050	1990–2020	1990–2030	1990–2040	1990–2050
2.A. Mineral industry	4.08	3.35	3.21	2.88	2.89	2.9	2.91	2.93	3	-29.45	-28.96	-28.23	-26.51
2.B. Chemical industry	2.94	2.80	1.63	2.19	2.13	2.06	2	1.94	2	-25.56	-29.97	-34.05	-32.01
2.C. Metal industry	9.81	7.08	5.95	6.96	6.77	6.82	6.78	6.78	6.78	-29.05	-30.48	-30.89	-30.89
2.D. Non-energy products from fuels and solvent use	0.13	0.14	0.13	0.13	0.14	0.14	0.14	0.14	0.14	3.53	11.50	11.50	11.50
2.E. Electronics industry	NO	0.01	0.00	0.01	0.01	0.01	0.01	0.02	0.02	NA	NA	NA	NA
2.F. Product uses as substitutes for ODS	NO	1.46	4.02	3.7	2.46	1.66	1.08	0.79	0.59	NA	NA	NA	NA
2.G.Other product manufacture and use	0.29	0.32	0.29	0.29	0.28	0.27	0.26	0.26	0.25	-0.16	-7.04	-10.49	-13.93
2.H. Other	NO	0.00	0.00	0	0	0	0	0	0	NA	NA	NA	NA
Total	**17.25**	**15.15**	**15.23**	**16.16**	**14.67**	**13.86**	**13.18**	**12.85**	**12.77**	**-6.32**	**-19.65**	**-25.51**	**-25.97**

Source: CHMI

Figure 5.2: Reported and projected emissions of GHG in 2. IPPU – WEM scenario



Source: CHMI

Sensitivity analysis

Projections of GHG emissions from 2. IPPU sector are based on calculation sheets used for inventory emission estimates in NIR (CHMI, 2020). Activity data is only variable which changes during projected period 2019–2050. EFs are constant during projected period and thus sensitivity analysis would not bring any interesting outcomes for categories under 2. IPPU sector (except category 2.F.1).

Only category where sensitivity analysis could bring interesting output is category 2.F.1 Refrigeration and air conditioning, which is also a key category (CHMI, 2020). The projections are prepared with national model Phoenix (see chapter 5.3 Methodology, Tab. 5.50), which takes into account a specific approach for calculating the amount of chemicals remaining in the equipment at decommissioning, using the Gaussian distribution model with mean at the lifetime expectancy for newly filled equipment and assuming only half lifetime expectancy for serviced equipment. Sensitivity analysis for category 2.F.1 is implemented using variable consumption of F-gases by ±5%, while respecting the emission trend from NIR (CHMI, 2020).

Table 5.18: Sensitivity analysis using variable consumption of F-gases in category 2. F.1 under IPPU sector

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

Source: CHMI

Difference between previously and currently reported projections

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

5.1.4 Agriculture (Sector 3)

Projections of greenhouse gas emissions include the following activities:

CH_4 emissions

- Enteric fermentation,
- Manure management.

N_2O emissions

- Manure management,
- Agricultural soils.

CO_2 emissions

- Liming,
- Urea application.

The projections presented in this report are based on the methodology used in the National Inventory Report (CHMI, 2020) in the Agriculture sector. Trends in activity data and the emission factors (EF) used in calculation were derived from the official documents (MoA, 2016) of the Ministry of Agriculture of the Czech Republic (further only Ministry of Agriculture), from discussions with relevant experts of the Ministry of Agriculture (Section of Agriculture and Food Production, (MoA, 2020)) and from the cooperating experts of the Crop Research Institute (Klír & Wollnerová, 2020). There are no additional measures planned to decrease GHG emissions in the Agriculture sector currently. Therefore, only WEM scenario was calculated.

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

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

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

For some activity data it was very difficult to forecast the future development (e.g., the amount of sewage sludge applied to soils etc.), and in such cases the constant values were therefore used in estimation. The projected emissions in Agriculture retain the trend in the emissions reported for the 1990–2018 period (CHMI, 2020) considering the status and hypothetical developments in this sector. The trend series are consistent for both methane (CH_4) and nitrous oxide (N_2O). For CH_4, the decrease in emissions for enteric fermentation and manure management since 1990 relates to the decrease in the number of livestock (especially cattle and swine). Since 1994, it seems that agrarian conditions have settled down to the current level. The reduction of livestock population after 1990 is partly counterbalanced by an increase in cattle efficiency (increasing gross energy intake and milk production, body weight etc.) and by slight increase of populations.

Methane emissions

The sector development strategy published by the Ministry of Agriculture (MoA, 2016) (MoA, 2018) and validated by expert judgement (MoA, 2020) was used for the prediction. The cattle population rapidly declined during 1990–2011 (more than 60%). From 2012 the cattle population is slowly growing (about 0.5 - 2% per year) and similar trend is predicted for the period 2025 - 2050. The more intensive growth is predicted for swine population, specifically an increase by 47% within 2020–2050, and for poultry population with growth by up to 11% from 2020 to 2050.

Table 5.19: Values of calculated emission factor (EF) for enteric fermentation for dairy cattle, relevant milk production and body weight, projected data within time period 1990–2050

Dairy cattle	**Reported data**			**Projected data**						
	1990	**2005**	**2020**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
EF for enteric fermentation (kg CH_4/head/year)	98	128	160	156	156	162	162	167	167	171
Milk production (kg/day)	11	18	25	25	25	27	27	28	28	29
Body weight (kg)	520	585	650	670	670	670	670	670	670	670

Source: MoA, 2020

Table 5.20: Activity data – livestock population within reported and projected period

Livestock population (in 1000s)	**Reported data**			**Projected data**						
	1990	**2005**	**2020**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Cattle	3 506	1 392	1 404	1 404	1 420	1 450	1 470	1 500	1 520	1 550
Swine	4 790	2 877	1 499	1 499	1 600	1 700	2 000	2 200	2 200	2 200
Sheep	430	140	204	204	210	215	215	220	220	220
Goats	41	13	29	29	30	32	32	35	35	35
Horses	27	21	38	38	40	40	42	45	45	50
Poultry	31 981	25 372	24 247	24 247	24 200	25 000	25 500	26 000	26 500	27 000

Source: MoA, 2020

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

Nitrous oxide emissions

Direct and indirect emissions from manure management depend on livestock population and AWMS that is currently applied. Tier 2 (cattle) and Tier 1 (other livestock categories) are used for the associated GHG estimation in the National Inventory Report (CHMI, 2020). Livestock population data, mainly numbers of cattle, swine, and poultry, are decisive for the projection. The total N_2O emissions from Manure Management rapidly decreased by 50% during the period 1990–2015 (CHMI, 2020). Another decrease by about 15 % occurred in this category within the period 2016–2018 when a new category of the manure management system was reflected in the inventory (anaerobic digestion).

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 (MoA, 2016) on development of sowing areas for agricultural crops and on some observed trends in demands of the Czech food consumer as well. According to the strategical expectations of the Ministry, the total crop area used for cereals production decreases to 1300000 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 emission coefficients used for estimation of the N_2O emissions were taken from the National Inventory Report (CHMI, 2020). The methodology of emission estimation corresponds to the IPCC 2006 Gl (IPCC, 2006) and the emission categories are based on the common reporting format (CRF).

Table 5.21: Activity data – application of mineral fertilizers within projected period

Mineral fertilizers	**Reported data**			**Projected data**					
[kt N]	**1990**	**2005**	**2020**	**2020**	**2025**	**2030**	**2035**	**2040**	**2050**
	418	293	285	350	350	350	350	350	350

Source: CZSO, MoA 2020

Table 5.22: Activity data – annual harvests within projected period

Annual Harvest	**Reported data**			**Projected data**					
[kt]	**1990**	**2005**	**2020**	**2020**	**2025**	**2030**	**2035**	**2040**	**2050**
Crops (cereals)	8 947	7 660	8 127	6 978	6 865	6 978	7 053	7 051	7 000
Pulses	152	96	92	70	80	93	93	94	90
Potatoes	1755	1013	696	622	662	722	724	726	700
Sugar beet	4 026	3 496	3 671	3 728	3 760	3 804	3 843	3 866	3 866

Source: CZSO, MoA 2020

Carbon dioxide emissions

Increase by about 13% is predicted for consumption of limestone included dolomite and increase by about 60 % is predicted for consumption of urea, predicted period for both is 2020–2050. The predicted values represent an upper estimate. Tier 1 methods are used for estimation of CO_2 emissions from both sources (CHMI, 2020).

Table 5.23: Activity data – application of limestone and urea within reported and projected period

Applied [kt]	**Reported data**			**Projected data**						
	1990	2005	2020	2020	2025	2030	2035	2040	2045	2050
Lime	2 677	145	397	400	450	450	450	450	450	450
Urea	148	200	213	400	400	400	400	400	400	400

Source: CZSO, MoA, 2020

Projection results – WEM scenario

Most policies and measures, including objectives of conceptual strategy, originate from the Strategy of Ministry of Agriculture (MoA, 2016, MoA, 2020). 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.

Table 5.24: Policies and Measures included in projections in Agriculture - WEM scenario

PaM title	**Period of implementation**	**Gas affected**
Air protection Act (cross-cutting)	2002–2040	CO_2, CH_4, N_2O
The Climate Protection Policy of the Czech Republic (cross-cutting)	2017–2030	CO_2, CH_4, N_2O, SF_6, NF_3
Cross Compliance	2009–2035	CO_2, CH_4, N_2O
Strategy for growth in Agriculture	2013–2020	CO_2, CH_4, N_2O
Rural Development Program of the Czech Republic (2014–2020)	2014–2020	CO_2, CH_4, N_2O
Action Plan for the Development of Organic Farming in the CR (2016–2020)	2016–2020	CH_4, N_2O
Action Plan for biomass in the CR	2012–2020	CO_2
Ministry of Agriculture Strategy with a view to the 2030	2016–2030	CH_4, N_2O
Nitrate Directive - 4th Action Plan	2016–2035	N_2O

Source: MoE

A relatively moderate increasing trend in the production of GHGs in Agriculture is expected, according to WEM scenario. The total emissions in 2050 should be approximately 8% above the total estimated in 2020.

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

Table 5.25: Reported and projected emissions of GHG in Agriculture – WEM scenario

[Mt CO_2eq.]	Reported emissions			Projected emissions						Difference [%]			
	1990	**2005**	**2020**	**2020**	**2025**	**2030**	**2035**	**2040**	**2050**	**1990–2020**	**1990–2030**	**1990–2040**	**1990–2050**
WEM	15.5	8.1	7.8	8.14	8.17	8.37	8.49	8.67	8.82	-47.53	-46.04	-44.11	-43.14

Source: CHMI

Table 5.26: Breakdown of reported and projected emissions of GHG by gases in Agriculture - WEM scenario

GHG	**Reported emissions**			**Projected emissions**						**Difference [%]**			
[Mt CO_2eq.]	**1990**	**2005**	**2020**	**2020**	**2025**	**2030**	**2035**	**2040**	**2050**	**1990–2020**	**1990–2030**	**1990–2040**	**1990-2050**
CO_2	1.30	0.21	0.34	0.47	0.47	0.47	0.47	0.47	0.47	-63.74	-63.74	-63.74	-63.74
CH_4	7.28	3.69	3.44	3.44	3.46	3.62	3.7	3.83	3.97	-52.77	-50.30	-47.42	-45.50
N_2O	6.93	4.23	4.06	4.23	4.24	4.28	4.32	4.36	4.38	-38.98	-38.26	-37.11	-36.82
Total	**15.51**	**8.12**	**7.84**	**8.14**	**8.17**	**8.37**	**8.49**	**8.67**	**8.82**	**-47.53**	**-46.04**	**-44.11**	**-43.14**

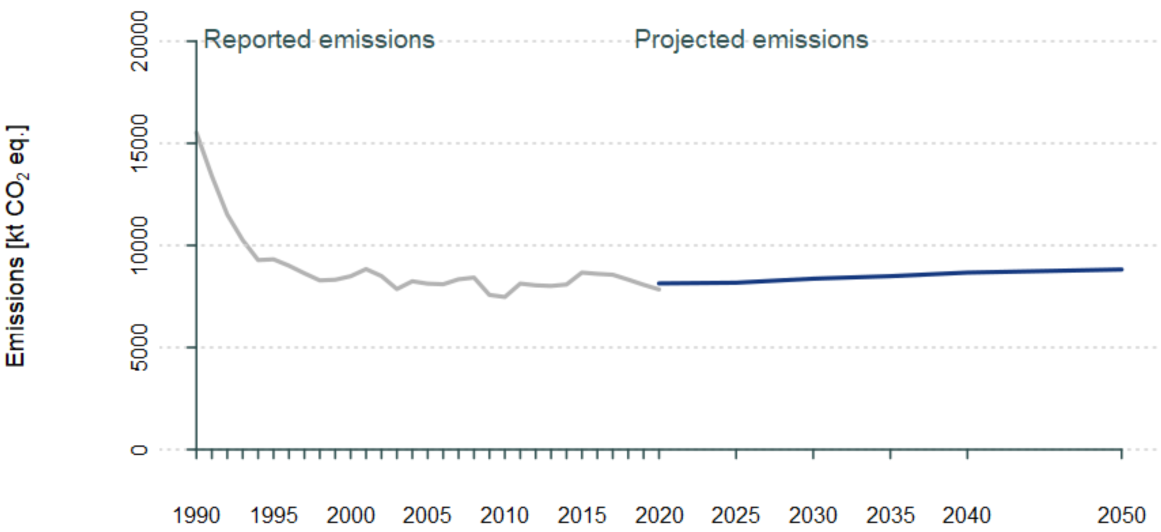
Source: CHMI

Table 5.27: Breakdown of the reported and projected emissions of GHG by categories in Agriculture - WEM scenario

GHG source category	**Reported emissions**			**Projected emissions**						**Difference [%]**			
[Mt CO_2eq.]	**1990**	**2005**	**2020**	**2020**	**2025**	**2030**	**2035**	**2040**	**2050**	**1990–2020**	**1990–2030**	**1990–2040**	**1990–2050**
3.A Enteric fermentation	5.74	2.84	3.09	3.1	3.11	3.25	3.3	3.41	3.54	-45.97	-43.35	-40.56	-38.30
3.B Manure management	2.94	1.58	0.79	0.77	0.79	0.81	0.86	0.9	0.92	-73.82	-72.46	-69.40	-68.72
3.D Agricultural soils	5.54	3.49	3.62	3.8	3.81	3.83	3.86	3.89	3.89	-31.38	-30.84	-29.76	-29.76
3.G Liming	1.19	0.06	0.18	0.18	0.18	0.18	0.18	0.18	0.18	-84.84	-84.84	-84.84	-84.84
3.H Urea application	0.11	0.15	0.16	0.29	0.29	0.29	0.29	0.29	0.29	167.20	167.20	167.20	167.20
Total	**15.51**	**8.12**	**7.84**	**8.14**	**8.17**	**8.37**	**8.49**	**8.67**	**8.82**	**-47.53**	**-46.04**	**-44.11**	**-43.14**

Source: CHMI

Figure 5.3: Reported and projected emissions of GHG in 3. Agriculture – WEM scenario



Source: CHMI

<u>Sensitivity analysis</u>

Projections of greenhouse gas emissions from Agriculture sector are based on calculation sheets used for emission estimates in National Inventory Report (CHMI 2020). It uses activity data projected for the period 2020–2050. Most of the emission factors remain constant during the projected period and thus sensitivity analysis would not bring any interesting outcomes. There is one exception – cattle EF for enteric fermentation, which depends on cattle productivity.

Table 5.28: The comparison of projected values of CH_4 emission factor (EF) for enteric fermentation, sensitivity of calculation

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

Source: CHMI

Differences between previously and currently reported projections

The current projection estimates are lower than those of the earlier projections. The forecasted smaller livestock population growth produces a lower level of GHG emissions in the projected period. The increase of emissions between years 2005 and 2030 was 16% for earlier projections (2019) and 3% for the current projections.

5.1.5 Land Use, Land-Use Change and Forestry (Sector 4)

Land use, land-use change and forestry (LULUCF) is a specific sector within the emission inventory framework, as it is the only one able to directly offset CO_2 emissions due to photosynthetic fixation of carbon in plants and increasing individual ecosystem carbon pools. Projections for LULUCF include the following activities:

CO_2 emissions

- Cropland,
- Wetlands,
- Settlements,
- Other land.

CO_2 removals

- Forest land,
- Grassland,
- Harvested wood products.

CH_4 emissions

- Forest land.

N_2O emissions

- Forest land.

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 2020) are exclusively based on the cadastral land use information of the Czech Office for Surveying, Mapping and Cadastre (COSMC; www.cuzk.cz). The land-use representation and the land-use change identification system of the 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 the National Inventory Report (CHMI 2020). Any additional intervention under WAM scenario would likely not have effects larger than uncertainties associated with addressing and development of the current unprecedented disturbance to forestry. Therefore, no WAM scenario was elaborated.

The projections beyond 2018 are based on the observed trends and anticipation of gradually diminishing category-specific land use changes until 2050. 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.

*Table 5.29: Land use areas (kha): projected until 2050 (*IE - areas of 4.F Other land are included within 4.E Settlements)*

Land use category	Reported area [kha]			Projected area [kha]					
	1990	2005	2020	2020	2025	2030	2035	2040	2050
4.A Forest land	2629	2647	2677	2678	2685	2689	2692	2695	2695
4.B Cropland	3455	3286	3178	3156	3123	3098	3079	3064	3041
4.C Grassland	833	974	1023	1033	1048	1061	1073	1083	1100
4.D Wetlands	158	161	167	166	168	169	171	173	176
4.E Settlements	812	819	842	854	864	870	873	874	875
4.F Other land*	IE	IE	IE	IE	IE	IE	IE	IE	IE

Source: CHMI, IFER Ltd.

Following the setup of land use areas, the projections of emission estimates are prepared. Specific attention is given to forest land, which always represents the key emission category of the LULUCF sector as well as within the entire Czech National Inventory. The Operational Scale Carbon Budget Model of the Canadian Forest Service (CBM-CFS3, v. 1.2) (Kull, et al., 2016) was chosen for this study (for detailed information see chapter 5.3 Methodology, Tab. 5.50).

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

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

Projection results – WEM and WAM scenario

The WEM scenario includes the development of land areas of individual land use categories. 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 for the individual land use categories with exception of CO_2 emissions from Forest Land and HPW emission contribution.

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

Table 5.30: Policies and Measures included in projections in LULUCF - WEM scenario

PaM title	Period of implementation	Gas affected
The Climate Protection Policy of the Czech Republic (cross-cutting)	2017–2030	CO_2, CH_4, N_2O, SF_6, NF_3
Updated Recommendations for implementing the proposed measures of NLP II	2018–2035	CO_2

Source: MoE

The WEM scenario represents an adaptive scenario for the Czech forestry. It will result in a more rapid conversion of productive, but instable coniferous stands into a more resilient, dominantly broadleaved and/or mixed forest stands.

Table 5.31: Reported and projected emissions of GHG in 4. LULUCF sector – WEM scenario

[Mt CO_2eq.]	Reported emissions			Projected emissions						Difference			
	1990	2005	2020	2020	2025	2030	2035	2040	2050	1990–2020	1990–2030	1990–2040	1990–2050
WEM	-8.94	-8.34	12.77	12.93	0.75	-1.98	-5.08	-7.19	-6.08	-244.72	-77.85	-19.52	-31.99

Source: CHMI

Table 5.32: Breakdown of reported and projected emissions of GHG by gases in 4. LULUCF sector - WEM scenario

[Mt CO_2eq.]	Reported emissions			Projected emissions						Difference [%]			
	1990	2005	2020	2020	2025	2030	2035	2040	2050	2020–1990	2030–1990	2040–1990	2050–1990
CO_2	-9.03	-8.43	12.72	12.87	0.69	-2.04	-5.14	-7.25	-6.14	-242.54	-77.42	-19.70	-32.05
CH_4	0.05	0.05	0.03	0.03	0.03	0.03	0.03	0.03	0.03	-36.84	-36.84	-36.84	-36.84
N_2O	0.04	0.04	0.02	0.03	0.03	0.03	0.03	0.03	0.03	-36.82	-36.82	-36.82	-36.82
Total	**-8.94**	**-8.34**	**12.77**	**12.93**	**0.75**	**-1.98**	**-5.08**	**-7.19**	**-6.08**	**-244.72**	**-77.85**	**-19.52**	**-31.99**

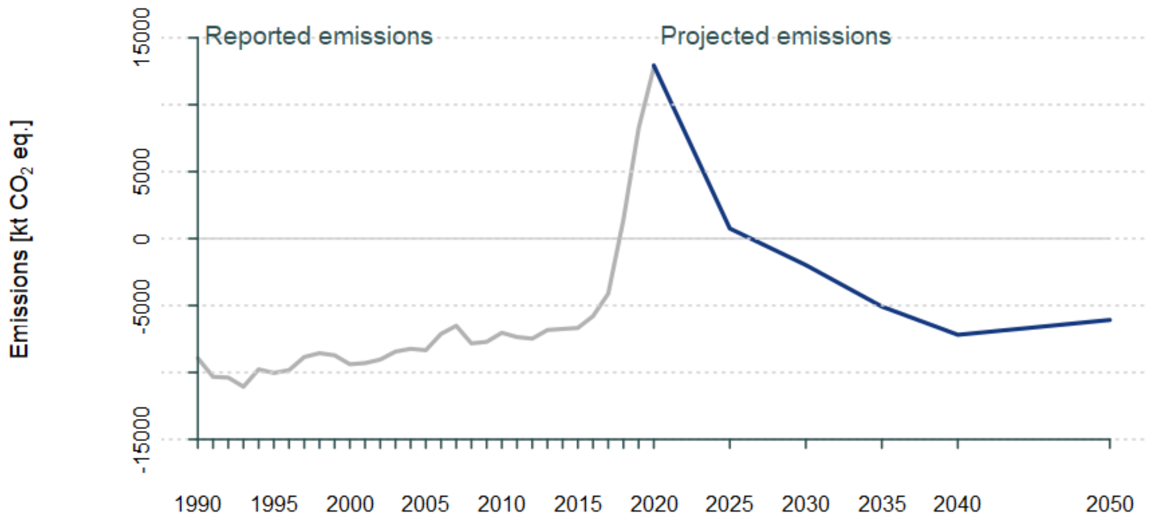
Source: CHMI

Table 5.33: Breakdown of reported and projected emissions of GHG by category in 4. LULUCF sector - WEM scenario

[Mt CO_2eq.]	Reported emissions			Projected emissions						Difference [%]			
	1990	2005	2020	2020	2025	2030	2035	2040	2050	2020–1990	2030–1990	2040–1990	2050–1990
4.A Forest land	-7.50	-6.88	14.78	19.45	3.28	-0.70	-4.50	-7.09	-5.75	-359.43	-90.65	-5.38	-23.35
4.B. Cropland	0.10	0.11	0.03	0.16	0.16	0.16	0.16	0.16	0.16	56.34	56.34	56.34	56.34
4.C Grassland	-0.16	-0.41	-0.49	-0.37	-0.36	-0.36	-0.36	-0.36	-0.37	132.64	126.28	126.28	132.64
4.D Wetlands	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	18.33	18.33	18.33	18.33
4.E Settlements	0.28	0.25	0.15	0.15	0.15	0.15	0.15	0.15	0.15	-47.40	-47.40	-47.40	-47.40
4.G HWP	-1.68	-1.43	-1.73	-6.48	-2.50	-1.25	-0.54	-0.07	-0.29	285.63	-25.62	-95.90	-82.66
Total	**-8.94**	**-8.34**	**12.77**	**12.93**	**0.75**	**-1.98**	**-5.08**	**-7.19**	**-6.08**	**-244.72**	**-77.85**	**-19.52**	**-31.99**

Source: CHMI

Figure 5.4: Reported and projected emissions of GHG in 4. LULUCF – WEM scenario



Source: CHMI

Sensitivity analysis

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

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

Differences between previously and currently reported projections

There is no fundamental methodological difference in the concept of the 4. LULUCF projections, but the tool used for quantifying the emissions for 4.A Forest land changed. This submission used CBM-CSF3 model, while previously, EFISCEN was used for projecting forest resource and the associated ecosystem carbon balance. More details are given in Section 5.3 Methodology, Tab. 5.49, 5.50.

Much more fundamental change represents the recent tragic development in the Czech forestry, which experiences an unprecedented drought-induced decline of coniferous forest stands, with an exceptional bark-beetle outbreak. The associated increase of salvage logging turned 4.A

Forest land and the entire 4. LULUCF sector into a significant GHG source in 2018 (CHMI, 2020). This is for the first time during the reporting period since 1990. As of late 2020, it is known that emissions from 4.A further increased during 2019 (Emil Cienciala, unpublished data). This information, specifically the harvest levels naturally affected the construction of the WEM scenario as elaborated in the current text.

5.1.6 Waste (Sector 5)

The waste sector comprises emissions from human activities associated with general waste management. Projections include the following activities:

CO_2 emissions

- Waste incineration

CH_4 emissions

- Solid waste disposal,
- Biological treatment of solid waste,
- Incineration and open burning of waste,
- Waste water treatment and discharged.

N_2O emissions

- Biological treatment of solid waste,
- Incineration and open burning of waste,
- Waste water treatment and discharged.

The overall development of the waste sector in the past decades is dominated by the landfilling (Solid Waste Disposal Sites - SWDS) of waste. Landfilling is still the dominant type of waste management nowadays, but its importance is decreasing due to the rise of waste recycling; collection of separated waste parts, composting, and energy recovery. In a 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 the Circular Economy Package (EC 2018). However, the steady increase in energy recovery and even the impressive leaps in composting and material recovery during the past four years did not lead to a decrease in landfill due to a steady increase in total amount of MW (CHMI 2020).

The projections of greenhouse gas emissions in waste sector are based on data and methodology used for emission estimates reported in the National Inventory Report (CHMI 2020). Activity data reported in the National Inventory Report (CHMI 2020) are obtained from the 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 National Inventory Report (CHMI 2020) 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, activity data and parameters up to current reporting year are from the common reporting format (CRF) and VISOH. From 2018 to 2050, extended time series were aligned with assumptions from the Waste Management Plan 2014 (WMP) (MoE, 2014) and by the obligations of the CEP (EC, 2018). The forecasted scenario in the WMP (MoE, 2014) was the guiding pathway for updating the projections.

Projection results – WEM and WAM scenario

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

Scenario in WMP (MoE, 2014) fulfils description of WEM scenario, the document is taking into account all measures that are already in effect, although further measures will be implemented in the future, based on the roadmap proposed in WMP. For both WEM and WAM scenarios it is expected that emissions will be decreasing until 2050, compared to 2020. Decrease of emissions is more obvious for WAM scenario which takes into account stricter LFG (landfill gas) recovery coefficients after 2025. The expected total emissions from 5. Waste should decrease by 3% according WEM and decrease by 12% according WAM between 1990 and 2050.

Table 5.34: Reported and projected emissions of GHG in Waste – WEM and WAM scenarios

[Mt CO_2eq.]	Reported emissions			Projected emissions						Difference [%]			
	1990	2005	2020	2020	2025	2030	2035	2040	2050	1990–2020	1990–2030	1990–2040	1990–2050
WEM	3.01	3.96	5.14	5.66	5.33	4.65	3.84	3.35	2.92	87.69	54.40	11.22	-3.08
WAM	3.01	3.96	5.14	5.66	5.26	4.59	3.77	3.21	2.65	87.69	52.13	6.64	-12.15

Source: CHMI

WEM scenario

Development of the WEM scenario is based on following assumptions: MW production is decreasing slightly, landfilling is gradually declining and composting and energy recovery is taking place instead (MoE, 2014) within the 10% landfill limit by 2035 as per CEP (EC, 2018).

Table 5.35: Policies and Measures included in projections in Waste - WEM scenario

PaM title	Period of implementation	Gas affected
Air protection Act (cross-cutting)	2002–2040	CO_2, CH_4, N_2O
The Climate Protection Policy of the Czech Republic (cross-cutting)	2017–2030	CO_2, CH_4, N_2O, SF_6, NF_3
Circular Economy Package (CEP)	2018–2030	CH_4
Waste Management Plan 2014	2015–2024	CH_4

Source: MoE

Tab. 5.36: Breakdown of reported and projected emissions of GHG by gases in Waste - WEM scenario

[Mt CO_2eq.]	Reported emissions			Projected emissions						Difference [%]			
	1990	**2005**	**2020**	**2020**	**2025**	**2030**	**2035**	**2040**	**2050**	**1990–2020**	**1990–2030**	**1990–2040**	**1990–2050**
CO_2	0.02	0.10	0.10	0.14	0.16	0.17	0.19	0.21	0.24	603.63	771.25	938.87	1106.49
CH_4	2.76	3.61	4.75	5.24	4.88	4.18	3.34	2.83	2.34	89.97	51.56	2.49	-15.05
N_2O	0.23	0.24	0.28	0.27	0.29	0.30	0.31	0.32	0.34	16.95	26.78	35.02	43.22
Total	**3.01**	**3.96**	**5.14**	**5.66**	**5.33**	**4.65**	**3.84**	**3.35**	**2.92**	**87.69**	**54.40**	**11.22**	**-3.08**

Source: CHMI

Table 5.37: Breakdown of reported and projected emissions of GHG by categories in Waste - WEM scenario

[Mt CO_2eq.]	Reported emissions			Projected emissions						Difference [%]			
	1990	**2005**	**2020**	**2020**	**2025**	**2030**	**2035**	**2040**	**2050**	**1990–2020**	**1990–2030**	**1990–2040**	**1990–2050**
5.A Solid waste disposal	1.79	2.74	3.29	3.72	3.34	2.63	1.79	1.27	0.78	107.34	46.87	-29.12	-56.53
5.B Biological treatment of solid waste	NE,IE	0.06	0.74	0.73	0.76	0.79	0.82	0.85	0.91	NA	NA	NA	NA
5.C Incineration and open burning of waste	0.02	0.11	0.11	0.14	0.16	0.18	0.19	0.21	0.24	597.11	763.17	929.24	1095.31
5.D Waste water treatment and discharge	1.20	1.04	0.99	1.07	1.07	1.06	1.04	1.02	0.99	-10.91	-12.04	-14.82	-17.64
5.E Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Total	**3.01**	**3.96**	**5.14**	**5.66**	**5.33**	**4.65**	**3.84**	**3.35**	**2.92**	**87.69**	**54.40**	**11.22**	**-3.08**

Source: CHMI

WAM scenario

For both WEM and WAM scenarios all planned changes in waste management practice are implemented according to the WMP (MoE, 2014) and by the new obligations of the CEP (EC, 2018). The difference between WEM and WAM scenarios is an increased recovery of landfill gas, which is raising more sharply in WAM scenario due to amplified pressure from renewables market.

Table 5.38: Breakdown of reported and projected emissions of GHG by gases in Waste - WAM scenario

[Mt CO_2eq.]	Reported emissions			Projected emissions						Difference [%]			
	1990	**2005**	**2020**	**2020**	**2025**	**2030**	**2035**	**2040**	**2050**	**1990–2020**	**1990–2030**	**1990–2040**	**1990–2050**
CO_2	0.02	0.10	0.10	0.14	0.16	0.17	0.19	0.21	0.24	603.63	771.25	938.87	1106.49
CH_4	2.76	3.61	4.75	5.24	4.82	4.11	3.27	2.69	2.07	89.97	49.08	-2.52	-24.95
N_2O	0.23	0.24	0.28	0.27	0.29	0.30	0.31	0.32	0.34	16.95	26.78	35.02	43.22
Total	3.01	3.96	5.14	5.66	5.26	4.59	3.77	3.21	2.65	87.69	52.13	6.64	-12.15

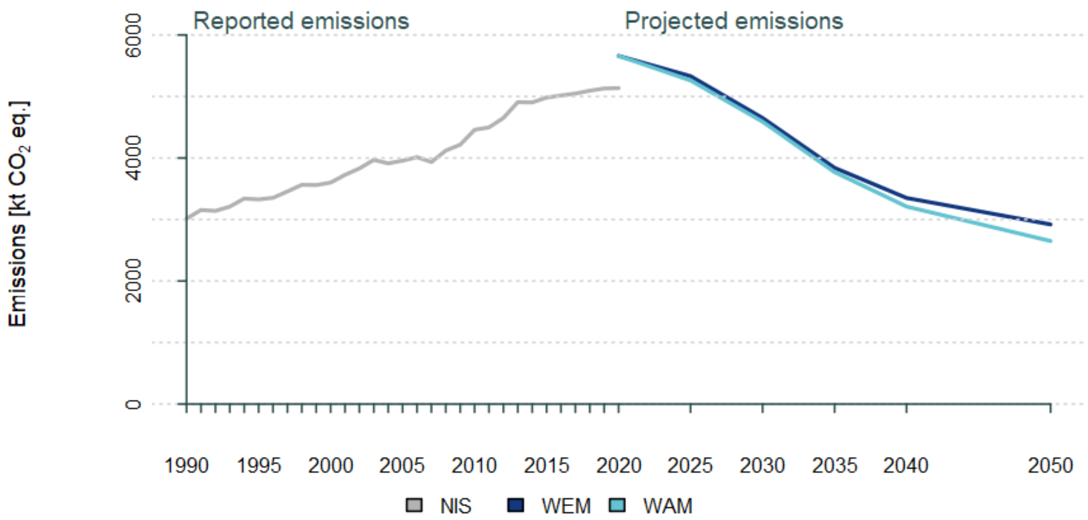
Source: CHMI

Table 5.39: Breakdown of reported and projected emissions of GHG by categories in Waste - WAM scenario

[Mt CO_2eq.]	Reported emissions			Projected emissions						Difference [%]			
	1990	**2005**	**2020**	**2020**	**2025**	**2030**	**2035**	**2040**	**2050**	**1990–2020**	**1990–2030**	**1990–2040**	**1990–2050**
5.A Solid waste disposal	1.79	2.74	3.29	3.72	3.27	2.56	1.72	1.13	0.51	107.34	43.06	-36.83	-71.77
5.B Biological treatment of solid waste	NE,IE	0.06	0.74	0.73	0.76	0.79	0.82	0.85	0.91	NA	NA	NA	NA
5.C Incineration and open burning of waste	0.02	0.11	0.11	0.14	0.16	0.18	0.19	0.21	0.24	597.11	763.17	929.24	1095.31
5.D Waste water treatment and discharge	1.20	1.04	0.99	1.07	1.07	1.06	1.04	1.02	0.99	-10.91	-12.04	-14.82	-17.64
5.E Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Total	**3.01**	**3.96**	**5.14**	**5.66**	**5.26**	**4.59**	**3.77**	**3.21**	**2.65**	**87.69**	**52.13**	**6.64**	**-12.15**

Source: CHMI

Figure 5.5: Reported and projected emissions of GHG in 5. Waste – WEM and WAM scenarios



Source: CHMI

<u>Sensitivity analysis</u>

Projections of greenhouse gas emissions from the Waste sector are based on calculation sheets used for emission estimates in the National Inventory Report (CHMI 2020). The emission factors are constant during the projected period and thus the 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.

Differences between previously and currently reported projections

In category 5.A Solid waste disposal, NIR (CHMI, 2020) and VISOH indicate 2.9 Mt of landfill MW in 2019, making the previously applied 1.9Mt for 2020 from the WMP (MoE, 2014) infeasible for use in projections. 1 Mt drop in landfill waste is not foreseen in a single year 2020. Instead of using direct values from the WMP(MoE, 2014), linear extrapolation was aligned with the same WMP (MoE, 2014) assumptions that MW total will decrease slightly, landfilling can be reduced to a small amount or phased out completely by 2030 or soon after, and with CEP assumption that max 10% from total MW by 2030 is allowed to be landfilled. CH_4emissions increased as a result of the new estimations. Impact of the change is slightly increasing CH_4 emissions compared to previous submission (2018) in category 5.A.

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

5.1.7 Total projections

The total GHG emissions are projected to slightly increase in next few years for both WEM and WAM scenarios. Around the 2025 the emissions will start to decrease and the declining trend continues until 2040 when it flattens and stays stagnant until 2050. The difference between WEM and WAM scenario is caused by additional measures in 1. Energy and 5. Waste. Total GHG emissions for WEM scenario are projected to amount to 74.15 Mt CO_2 eq. in 2050, representing 61% decrease of emissions compared to 1990. For WAM scenario the total GHG emissions in 2050 will amount to 54.88 Mt CO_2 eq., representing 71 % decrease of emissions compared to 1990.

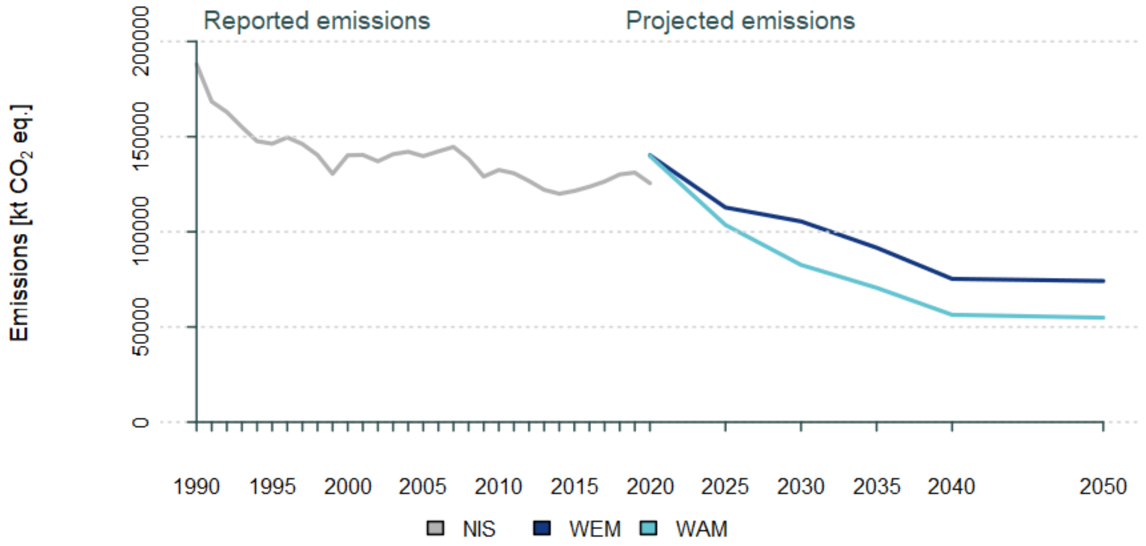
The highest share of GHG emissions in 2018 has sector 1. Energy (73%), where 97% comes from 1.A Fuel combustion. The share of other sectors on total GHG emissions is following: 2. IPPU 12%, 3. Agriculture 4% and 5. Waste 4%. 4. LULUCF is usually the only sector acting as GHG sink, however in 2018 it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

Table 5.40: Reported and projected emissions of GHG – WEM and WAM (including LULUCF) [Mt CO_2 eq., % reduction in comparison with 1990]

[Mt CO_2eq.]	Reported emissions			Projected emissions						Difference [%]			
	1990	**2005**	**2020**	**2020**	**2025**	**2030**	**2035**	**2040**	**2050**	**1990–2020**	**1990–2030**	**1990–2040**	**1990–2050**
WEM	188.02	139.76	125.56	140.17	112.77	105.46	91.65	75.26	74.15	-25.45	-43.91	-59.97	-60.56
WAM	188.02	139.76	126.56	139.86	103.59	82.60	70.57	56.37	54.88	-25.62	-56.07	-70.02	-70.81

Source: CHMI

Fig. 5.6: Total reported and projected GHG emissions – WEM, WAM scenario (including LULUCF)



Source: CHMI

Table 5.41: Information on updated greenhouse gas projections under a „with existing measures“ WEM scenario

Sector	GHG emissions and removals (kt CO_2 eq)						
	1990	1995	2000	2005	2010	2015	2020
1. Energy (including Transport)	161178.3	129378.5	122159.18	120865.45	112507.28	98861.9	84581.01
2. Industrial processes and product use	17250.05	14298.67	15347.04	15152.22	15112.9	15646.3	15229.96
3. Agriculture	15512.64	9317	8488.3	8123.81	7471.85	8667.76	7841.83
4. Land Use, Land-Use Change and Forestry	-8936.22	-10037.56	-9388.1	-8339.7	-7039.53	-6678.37	12771.8
5. Waste	3014.26	3326.69	3599.85	3956.47	4457.84	4982.58	5135.78
6. Other	NO	NO	NO	NO	NO	NO	NO
Total (including LULUCF)	**188019.02**	**146283.29**	**140206.27**	**139758.26**	**132510.35**	**121480.17**	**125560.38**
Total (excluding LULUCF)	**196955.24**	**156320.85**	**149594.37**	**148097.96**	**139549.87**	**128158.54**	**112788.58**

Sector	GHG emission projections (kt CO_2 eq)						
	2020	2025	2030	2035	2040	2050	
1. Energy(including Transport)	97287.08	83852.81	80559.09	71211.56	57579.62	55717.03	
2. Industrial processes and product use	16156.3	14670.23	13859.79	13183.41	12849.62	12774.54	
3. Agriculture	8137.3	8170.45	8369.14	8493.08	8668.08	8816.92	
4. Land Use, Land-Use Change and Forestry	12932.85	750.61	-1979.67	-5076.71	-7191.94	-6077.11	
5. Waste	5657.46	5328.16	4654.01	3839.77	3352.54	2921.38	
6. Other	NO	NO	NO	NO	NO	NO	
Total (including LULUCF)	**140170.99**	**112772.26**	**105462.36**	**91651.11**	**75257.92**	**74152.76**	
Total (excluding LULUCF)	**127238.14**	**112021.65**	**107442.03**	**96727.82**	**82449.86**	**80229.87**	

Gas	GHG emissions and removals (kt CO_2 eq)						
	1990	1995	2000	2005	2010	2015	2020
CO_2 emissions including net CO_2 from LULUCF	155179.55	121508.67	117693.63	117260.76	110346.9	98261.62	104573.3
CO_2 emissions excluding net CO_2 from LULUCF	164210.75	131627.14	127155.96	125688.56	117482.15	104995.66	91853.88
CH_4 emissions including CH_4 from LULUCF	23422.97	17970.32	15094.56	14587.43	14034.73	13428.87	11548.52
CH_4 emissions excluding CH_4 from LULUCF	23372.3	17926.27	15053.57	14537.66	13980.46	13398.78	11518.66
N_2O emissions including N_2O from LULUCF	9332.27	6620.06	6437.48	6333.31	5389.36	6162.23	5350.84
N_2O emissions excluding N_2O from LULUCF	9287.95	6583.19	6404.25	6294.98	5347.92	6136.66	5328.32
HFCs	NO	95.55	867.51	1450.02	2608.38	3544.88	4019.39
PFCs	NO	0.01	4.69	14.89	48.06	2.15	1.02
SF_6	84.24	88.68	108.4	111.84	82.76	78.27	65.16
NF_3	NO	NO	NO	NO	0.15	2.15	2.15
Total (including LULUCF)	**188019.02**	**146283.29**	**140206.27**	**139758.26**	**132510.35**	**121480.17**	**125560.38**
Total (excluding LULUCF)	**196955.24**	**156320.85**	**149594.37**	**148097.96**	**139549.87**	**128158.54**	**112788.58**

Gas	GHG emission projections (kt CO_2 eq)						
	2020	**2025**	**2030**	**2035**	**2040**	**2050**	
CO_2 emissions including net CO_2 from LULUCF	118037.30	93548.51	87655.26	75468.26	60151.04	59679.28	
CO_2 emissions excluding net CO_2 from LULUCF	105164.45	92857.91	89694.93	80604.97	67402.98	65816.39	
CH_4 emissions including CH_4 from LULUCF	12786.40	11155.97	10509.37	9456.21	8682.60	8045.53	
CH_4 emissions excluding CH_4 from LULUCF	12754.40	11123.97	10477.37	9424.20	8650.60	8013.53	
N_2O emissions including N_2O from LULUCF	5575.20	5545.72	5576.04	5594.00	5584.56	5791.32	
N_2O emissions excluding N_2O from LULUCF	5547.20	5517.72	5548.04	5566.00	5556.56	5763.32	
HFCs	3700.77	2459.09	1664.99	1080.88	791.9	593.86	
PFCs	0.7	0.85	1.02	1.19	1.35	1.67	
SF_6	67.11	57.88	50.50	44.50	39.58	32.53	
NF_3	3.50	4.25	5.17	6.07	6.89	8.57	
Total (including LULUCF)	**140170.99**	**112772.26**	**105462.36**	**91651.11**	**75257.92**	**74152.76**	
Total (excluding LULUCF)	**127238.14**	**112021.65**	**107442.03**	**96727.82**	**82449.86**	**80229.87**	

Source: CHMI

Table 5.42: Information on updated greenhouse gas projections under a „with additional measures“ WAM scenario

Sector	GHG emissions and removals (kt CO_2 eq)						
	1990	**1995**	**2000**	**2005**	**2010**	**2015**	**2020**
1. Energy (including Transport)	161178.30	129378.50	122159.18	120865.45	112507.28	98861.90	84581.01
2. Industrial processes and product use	17250.05	14298.67	15347.04	15152.22	15112.90	15646.30	15229.96
3. Agriculture	15512.64	9317.00	8488.30	8123.81	7471.85	8667.76	7841.83
4. Land Use, Land-Use Change and Forestry	-8936.22	-10037.56	-9388.10	-8339.70	-7039.53	-6678.37	12771.80
5. Waste	3014.26	3326.69	3599.85	3956.47	4457.84	4982.58	5135.78
6. Other	NO	NO	NO	NO	NO	NO	NO
Total (including LULUCF)	**188019.02**	**146283.29**	**140206.27**	**139758.26**	**132510.35**	**121480.17**	**125560.38**
Total (excluding LULUCF)	**196955.24**	**156320.85**	**149594.37**	**148097.96**	**139549.87**	**128158.54**	**112788.58**

Sector	GHG emission projections (kt CO_2 eq)						
	2020	2025	2030	2035	2040	2050	
1. Energy (including Transport)	96972.51	74736.67	57769.47	50202.38	38825.94	36712.83	
2. Industrial processes and product use	16156.30	14670.23	13859.79	13183.41	12849.62	12774.54	
3. Agriculture	8137.30	8170.45	8369.14	8493.08	8668.08	8816.92	
4. Land Use, Land-Use Change and Forestry	12932.85	750.61	-1979.67	-5076.71	-7191.94	-6077.11	
5. Waste	5657.46	5259.75	4585.60	3769.04	3214.31	2648.16	
6. Other	NO	NO	NO	NO	NO	NO	
Total (including LULUCF)	**139856.42**	**103587.71**	**82604.33**	**70571.21**	**56366.01**	**54875.33**	
Total (excluding LULUCF)	**126923.57**	**102837.10**	**84584.00**	**75647.92**	**63557.95**	**60952.44**	

Sector	GHG emissions and removals (kt CO_2 eq)						
	1990	1995	2000	2005	2010	2015	2020
CO_2 emissions including net CO_2 from LULUCF	155179.55	121508.67	117693.63	117260.76	110346.90	98261.62	104573.30
CO_2 emissions excluding net CO_2 from LULUCF	164210.75	131627.14	127155.96	125688.56	117482.15	104995.66	91853.88
CH_4 emissions including CH_4 from LULUCF	23422.97	17970.32	15094.56	14587.43	14034.73	13428.87	11548.52
CH_4 emissions excluding CH_4 from LULUCF	23372.30	17926.27	15053.57	14537.66	13980.46	13398.78	11518.66
N_2O emissions including N_2O from LULUCF	9332.27	6620.06	6437.48	6333.31	5389.36	6162.23	5350.84
N_2O emissions excluding N_2O from LULUCF	9287.95	6583.19	6404.25	6294.98	5347.92	6136.66	5328.32
HFCs	NO	95.55	867.51	1450.02	2608.38	3544.88	4019.39
PFCs	NO	0.01	4.69	14.89	48.06	2.15	1.02
SF_6	84.24	88.68	108.40	111.84	82.76	78.27	65.16
NF_3	NO	NO	NO	NO	0.15	2.15	2.15
Total (including LULUCF)	**188019.02**	**146283.29**	**140206.27**	**139758.26**	**132510.35**	**121480.17**	**125560.38**
Total (excluding LULUCF)	**196955.24**	**156320.85**	**149594.37**	**148097.96**	**139549.87**	**128158.54**	**112788.58**

Gas	GHG emission projections (kt CO_2 eq)						
	2020	2025	2030	2035	2040	2050	
CO_2 emissions incl. net CO_2 from LULUCF	117725.92	84450.04	64897.49	54493.32	41432.10	40709.35	
CO_2 emissions excl. net CO_2 from LULUCF	104853.07	83759.43	66937.16	59630.03	48684.04	46846.46	
CH_4 emissions incl. CH_4 from LULUCF	12786.40	11087.56	10440.96	9385.48	8544.38	7772.30	
CH_4 emissions excl. CH_4 from LULUCF	12754.40	11055.56	10408.96	9353.48	8512.38	7740.30	
N_2O emissions incl. N_2O from LULUCF	5572.01	5528.05	5544.19	5559.76	5549.81	5757.05	

Gas	GHG emission projections (kt CO_2 eq)						
	2020	2025	2030	2035	2040	2050	
N_2O emissions excl. N_2O from LULUCF	5544.01	5500.05	5516.19	5531.76	5521.81	5729.05	
HFCs	3700.77	2459.09	1664.99	1080.88	791.9	593.86	
PFCs	0.7	0.85	1.02	1.19	1.35	1.67	
SF_6	67.11	57.88	50.50	44.50	39.58	32.53	
NF_3	3.50	4.25	5.17	6.07	6.89	8.57	
Total (including LULUCF)	**139856.42**	**103587.71**	**82604.33**	**70571.20**	**56366.01**	**54875.33**	
Total (excluding LULUCF)	**126923.57**	**102837.10**	**84584.00**	**75647.91**	**63557.95**	**60952.44**	

Source: CHMI

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

Tab. 5.43 Split of historic and projected EU ETS and ESD emissions – WEM scenario

[Mt CO_2eq.]	Reported emissions		Projected emissions						Difference [%]			
	2005	2020	2020	2025	2030	2035	2040	2050	2005–2020	2005–2030	2005–2040	2005–2050
EU ETS	82.46	54.68	66.32	58.15	57.4	49.51	37.44	37.2	-19.57	-30.39	-54.60	-54.89
ESD	65.64	58.11	60.92	53.87	50.05	47.22	45.01	43.04	-7.19	-23.75	-31.43	-34.43

Source: CHMI, EEA

Tab. 5.44 Split of historic and projected EU ETS and ESD emissions – WAM scenario

[Mt CO_2eq.]	Reported emissions		Projected emissions						Difference [%]			
	2005	2020	2020	2025	2030	2035	2040	2050	2005–2020	2005–2030	2005–2040	2005–2050
EU ETS	82.46	54.68	66.32	54.11	44.39	38.64	28.85	28.6	-19.57	-46.17	-65.01	-65.32
ESD	65.64	58.11	60.61	48.72	40.19	36.99	34.69	32.33	-7.66	-38.77	-47.15	-50.75

Source: CHMI, EEA

5.1.8 Initial assumptions and scenarios

Political and legal environment

From a political and legal perspective, these following conditions have been taken into consideration with regard to the development of energy sector and industrial processes emitting GHGs:

- By acceding to the EU, the Czech Republic committed itself in terms of protection of the environment and climate, which form a part of the Acquis communautaire, such as Directive No. 80/2001/EC, Directive No. 96/61/EC (to be replaced by Directive 2010/75/EU in 2014), Directive No. 81/2001/EC (replaced by Directive 2016/2284/EU), Directive No. 96/2003/EC (replaced by Directive 2003/27/EC and Regulation (EC) No 1882/2003) and Directive No. 2003/30/EC (replaced by Directive 2009/28/EC).

- The ETS system is in operation in the Czech Republic as a part of the EU ETS. This system is developing especially in terms of allowance allocations, when the so-called grandfathering is being gradually abandoned and auctions are the main source of allowances (since 2013).
- The Czech Republic is bound by a number of international climate and environmental protection treaties (Kyoto Protocol, Second Sulphur Protocol, Gothenburg Protocol).
- Energy market is open to all comers pursuant to Act No. 458/2000 Coll. amended by Act No. 670/2004 Coll. (electricity from 1. 1. 2006, gas 1. 1. 2007) and by Act No. 158/2009. Coal, gas and electricity prices are converging with European market prices.
- Act No. 165 of 31 January 2012 on promoted energy sources and on amendment to some laws governs the support of renewable energy sources and of combined and heat power.

Technological development

In the period between 2018 and 2050, there are anticipated significant developments in technologies for acquisition, conversion, transportation and use of energy sources. In the area of solid fuels used in electricity generation, the use will lead to sources with supercritical steam parameters and fluid technologies, which will considerably increase efficiency. Changes in solid fuels consumption can be also expected based on termination of mining locations in the Czech Republic. In the area of combined electricity and heat production, the improvement of technologies will allow construction of sources as close as possible to its consumers. Later, we anticipate the possible introduction and usage of small sources based on micro turbine and fuel cell technologies.

In the nuclear sector, new nuclear units will be introduced after 2036.

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

In terms of motor fuel, besides further decreasing consumption, a higher use of alternative fuels, which will be possible also by use of renewable energy sources (biofuel) is anticipated. The main trend will be not only further decreased in measurable investment costs, but also due to criteria affecting protection of soil and biodiversity, respectively, demonstrable contributions to reducing greenhouse gas emissions.

Demographic development scenario

Population growth prognosis is based on the Czech Statistical Office (CzSO) data. The CzSO prepared four separate population projections; the medium variant was used.

Table 5.45: Demographic prognosis

	2018	**2020**	**2025**	**2030**	**2035**	**2040**	**2050**
Population (millions)	10.6	10.7	10.7	10.7	10.6	10.5	10.5

Source: CzSO

Economic development scenario

The scenarios of trends in the GDP used in this projection are based on predictions made by Ministry of Industry and Trade.

Table 5.46: Gross domoestic product prognosis (2016 constant prices) in million EUR

	2018	2020	2025	2030	2035	2040	2050
Constant prices	185 466	204 200	245 271	287 354	326 898	359 968	412 912

Source: MIT

Availability of domestic coal

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

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

Tab. 5.47 Projections of domestic coal mining, the updated trends in the capacities of mining

Brown coal [kt] (Name of mine)	**2018**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Libous	11 450	12 000	10 000	10 000	6 500	0	0	0
Bilina	9 450	9 600	8 500	8 500	7 000	4 500	4 500	4 500
CSA	3 670	3 500	0	0	0	0	0	0
Vrsany	7 770	7 500	7 500	7 500	7 500	7 500	5 500	5 500
Jiri and Druzba	6 850	6 000	5 500	5 000	4 000	3 000	0	0
Centrum	0	0	0	0	0	0	0	0
Total	**39 191**	**38 600**	**31 500**	**31 000**	**25 000**	**15 000**	**10 000**	**10 000**
Hard coal [kt] (Name of mine)	**2018**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
CSM	2 600	2 650	0	0	0	0	0	0
Karvinna - CSA	1 950	1 600	0	0	0	0	0	0
Karvinna - Lazy	0	0	0	0	0	0	0	0
Darkov	0	0	0	0	0	0	0	0
Paskov	0	0	0	0	0	0	0	0
Total	**4 550**	**4 250**	**0**	**0**	**0**	**0**	**0**	**0**

Source: MIT, 2020

Energy scenarios

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

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

5.2 Assessment of aggregate effect of policies and measures

The total effects of policies and measures for the WEM and WAM scenarios, aggregated and for each sector, are given in Table 5.48.

Table 5.48: Total effect of policies and measures in 2020 and 2030

Total Effect of Policies and Measures	Expected benefit in reducing greenhouse gas emissions (in kt CO_2 eq./year)	
	2020	2030
WEM Scenario		
Energy supply	6 697	6 503
Transport	1 289	2 347
Industrial Processes	3 152	4 775
Agriculture	575	912
Waste	854	1 304
LULUCF	458	395
Cross-cutting	2 740	6 624
Total Effect WEM	**16 765**	**22 860**
WAM Scenario		
Energy supply	0	4 451
Transport	126	142
Industrial Processes	0	0
Agriculture	0	0
LULUCF	0	0
Waste	0	0
Cross-cutting	0	17 500
Total Effect WAM	**126**	**22 093**
Total Aggregate Effect (WEM+ WAM)	**16 891**	**44 953**

Source: MoE

5.3 Methodology

The methodology used for the preparation of emission projections is in line with the methodology used for compilation of the Third, Fourth, Fifth, Sixth and the Seventh National Communication, which enables their mutual comparability. The methodology includes a set of the following actions:

1. Inventory of greenhouse gases,
2. Selection of the starting and the end year and cross-sectional years for projection,
3. Selection of own methodology and modelling tools for projections,
4. Collection and analysis of input data,
5. Determination of initial assumptions,
6. Definition of scenarios,
7. Calculation of scenarios and results presentation,
8. Sensitivity analysis of selected assumptions.

Results of these actions are described below.

Inventory of greenhouse gas emissions

The latest National Inventory Report available during the preparation of projections was published in 2021 (CHMI 2021) and contains emission estimates for 1990-2018. Summary data from this inventory are given in Chapter 3.

Starting year and cross-section periods

The year 2018 was selected as a base year for projections of greenhouse gas emissions. Year 2018 is the latest year with available information on macroeconomic development, energy balances and emission estimates. The year 2050 was selected as a final year, according to EU recommendations. The years 2020, 2025, 2030, 2035, 2040 and 2050 were selected as cross-cutting years.

Modelling tools and methods

Methodologies are also explained in related sector chapters. Information on Methodology changes from previous NC can be found in Tab. 5.49. Information on models Phoenix and CBM-CFS3 can be found in Tab.5.50.

For projections of CO_2, CH_4 and N_2O emissions from sector Energy (excluding 1.A.3 Transport) a data-driven model structure was used. The previous MESSAGE model was relatively laborious to enter data, did not allow some important aspects of the projections data types (e.g., what should be the energy mix to slow or fast decarbonization) and could not be used in cooperation with other institutions in the Czech Republic and neighboring countries. Projections of CO_2, CH_4 and N_2O emissions from category 1A3 Transport were performed by using methodology linked to data from COPERT.

Projections of CO_2, CH_4, N_2O, SF_6 and NF_3 emissions from sector industrial processes and product use are directly linked to the calculation sheets for emission estimates. In the case of projections of fluorinated greenhouse gases used as substitutes for ODS national model Phoenix was used (for more details see Tab. 5.50).

Projections of CO_2, CH_4, and N_2O emissions from sector agriculture are directly linked to the calculation sheets for emission estimates.

Projections related to Forest Land are elaborated on the basis of the Operational Scale Carbon Budget Model of the Canadian Forest Service (CBM-CFS3, v. 1.2 - for more details see Tab. 5.50). The projections of GHG emissions related to other land use categories besides 4.A Forest land (i.e., 4.B Cropland, 4.C Grassland, 4.D Wetlands, 4.E Settlements) are based on simple correlations of the estimated emissions for the reference year linked exclusively to the corresponding land areas for the predicted years. The exception is the emission contribution of 4.G HWP, which are newly reported under UNFCCC and Kyoto Protocol since the 2015 annual national inventory submission. Finally, the contribution of 4.G HWP was projected using the harvest activity data as reported in NIR (CHMI, 2020).

Projections of CO_2, CH_4, and N_2O emissions from sector waste are directly linked to the calculation sheets for emission estimates.

Some methodology, assumptions and changes occurred compared to NC7, mainly for sectors Energy, IPPU, LULUCF (because of the development in the Czech forestry) and Waste. The table below contains information about methodology changes compared to NC7.

Table 5.49: Methodology, assumptions and changes since the previous submission

Sector	**Methodology changes compared to NC7**
Energy	There were three main changes in the projections preparation in the 1. Energy sector compared to the previous submission: • The MESSAGE model (used in 2017 and 2019) was replaced by a data-driven model structure due to laborious data entry and incompatibility with models from neighbouring countries. • The European Green Deal came into force, which raises decarbonisation targets and brings new European and Czech policies and measures over the next two years. • There was a sharp increase in the prices of emission allowances in the last three years, which makes the system less predictable. Companies are likely to adapt their strategies to the situation and significantly change their fuel demands. • Projections for category 1.A.3 Transport were calculated in R-project unlike previous projections.
IPPU	Unlike previous projections (CHMI 2017), current projections are based on the methodology used in the National Inventory Report (CHMI 2020) 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. The increase in the current projection is also caused by changed approach to activity data projections, where the gases used for servicing were included in consumption next to the first fill, whose projections is decreasing according to adopted legislative measures.
Agriculture	Methodology used in the current report is the same that it was used in previous report. 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 (based on updated strategy published by Ministry of Agriculture (MoA, 2020), according to the recent development in the agriculture sector).

	The country specific data derived from the Czech legislation (Decree No.377/2013 Coll., On the storage and use of fertilizers) were used for the first time in this prediction; WEM and WAM scenarios used in 2017, from 2019 only WEM is used.
LULUCF	There has been no fundamental methodological difference in the concept of the 4. LULUCF projections, but the tool used for quantifying the emissions for 4.A Forest land changed. This submission used CBM-CSF3 model, while previously, EFISCEN was used for projecting forest resource and the associated ecosystem carbon balance. Much more fundamental change represents the tragic development in the Czech forestry, which experiences an unprecedented drought-induced decline of coniferous forest stands, with an exceptional bark-beetle outbreak. The associated increase of salvage logging turned 4.A Forest land and the entire 4. LULUCF sector into a significant GHG source in 2018 (CHMI, 2020).
Waste	In category 5.A Solid waste disposal, NIR (CHMI, 2020) and VISOH indicate 2.9 Mt of landfill MW in 2019, making the previously applied 1.9Mt for 2020 from the WMP (MoE, 2014) infeasible for use in projections. 1 Mt drop in landfill waste is not foreseen in a single year 2020. Instead of using direct values from the WMP (MoE, 2014), linear extrapolation was aligned with the same WMP (MoE, 2014) assumptions that MW total will decrease slightly, landfilling can be reduced to a small amount or phased out completely by 2030 or soon after, and with CEP assumption that max 10% from total MW by 2030 is allowed to be landfilled. CH_4 emissions increased as a result of the new estimations. Impact of the change is slightly increasing CH_4 emissions compared to previous submission (2017) in category 5.A. In category 5.B Composting, a slowing increase inactivity data trend from 2013 to 2018 is reflected by applying less rapidly increasing activity data driver for the 2020 submission resulting in slight decrease in CH_4 emissions projections. In category 5.D Waste water treatment, IEF for CH_4 and N_2O were applied to Eurostat (2020) population estimates, instead of single waste water treatment CO_2 eq. IEF for both emissions. CH_4 decreased and N_2O increased, but the total CO_2 eq. decreased slightly as a result. The total GHG emissions trend stayed stagnant.

Source: CHMI

Table 5.50: Detailed information on Phoenix and CBM-CSF3

Model 1	
Model name (abbreviation)	Phoenix
Full model name	Phoenix
Model version and status	1.6
Latest date of revision	December 2018
URL to model description	https://www.chmi.cz/files/portal/docs/reditel/SIS/casmz/assets/2018/chmu_mz_1-18.pdf
Model type	top-down model
Summary	Phoenix is country specific model developed by the Czech national inventory team for F-gases emission estimates used in refrigeration and air conditioning systems (category 2.F.1).
Intended field of application	Emissions estimates of F-gases used in refrigeration and air conditionig systems
Description of main input data categories and data sources	Phoenix is used for emission estimates and projection of emissions from categories under 2.F.1 (2.F.1.a, 2.F.1.b, 2.F.1.c, 2.F.1.d and 2.F.1.f (emissions from category 2.F.1.e are not estimated by using model Phoenix)). Input data represent data about consumption of specific gas in category 2.F.1.
Validation and evaluation	-
Output quantities	Emissions in kt CO_2 eq.

GHG covered	HFC's and PFC's
Sectoral coverage	Industrial Processes and Product Use
Geographical coverage	Czech Republic
Temporal coverage (e.g. time steps, time span)	one year time step
Other models which interact with this model, and type of interaction (e.g. data input to this model, use of data output from this model)	no interface with other models
Input from other models	no input from other models
References to the assessment and the technical reports that underpin the projections and the models used	https://www.chmi.cz/files/portal/docs/reditel/SIS/casmz/assets/2018/chmu_mz_1-18.pdf
Model structure (if diagram please attach to your submission in Reportnet)	https://www.chmi.cz/files/portal/docs/reditel/SIS/casmz/assets/2018/chmu_mz_1-18.pdf
Strenghts	Takes into account the phasing out F-gases. Simulates a natural process of F-gases leakages from equipement over the years
Weaknesses	Relatively high uncertainty in the distribution of F-gases according to the specific use.
Model 2	
Model name (abbreviation)	CBM-CSF3
Full model name	Carbon Budget Model of the Canadian Forest Sector
Model version and status	Ver. 1.2
Latest date of revision	2019, 2020
URL to model description	https://www.nrcan.gc.ca/climate-change/impacts-adaptations/climate-change-impacts-forests/carbon-accounting/carbon-budget-model/13107
Model type	Empirical forest model
Summary	Empirical forest model, used in several EU countries and in JRC for analysis of forest resource development and impact on carbon budget
Intended field of application	Forest and forestry
Description of main input data categories and data sources	The operational-scale Carbon Budget Model of the Canadian Forest Sector (CBM-CFS3) is an aspatial, stand- and landscape-level modeling framework that simulates the dynamics of all forest carbon stocks required under the Kyoto Protocol (aboveground biomass, belowground biomass, litter, dead wood and soil organic carbon). It complies with the carbon estimation methods outlined in the Intergovernmental Panel on Climate Change (IPCC) Good Practice Guidance For Land Use, Land-Use Change and Forestry (2003) report. The model uses much the same information as is required for forest management planning (e.g., forest inventory, tree species, growth and yield curves, natural and human-induced disturbance information, forest harvest schedule and land-use change information), supplemented with information from national ecological parameter databases.
Validation and evaluation	https://www.nrcan.gc.ca/climate-change/impacts-adaptations/climate-change-impacts-forests/carbon-accounting/carbon-budget-model/13107
Output quantities	https://www.nrcan.gc.ca/climate-change/impacts-adaptations/climate-change-impacts-forests/carbon-accounting/carbon-budget-model/13107
GHG covered	CO_2
Sectoral coverage	LULUCF, Forest land
Geographical coverage	Country or region - Czech Republic in this application
Temporal coverage (e.g. time steps, time span)	annual time step, projection time several decades
Other models which interact with this model, and type of interaction (e.g. data	timber supply models if requested

input to this model, use of data output from this model)	
Input from other models	timber supply models if requested
References to the assessment and the technical reports that underpin the projections and the models used	https://www.nrcan.gc.ca/climate-change/impacts-adaptations/climate-change-impacts-forests/carbon-accounting/carbon-budget-model/13107
Model structure (if diagram please attach to your submission in Reportnet)	https://www.nrcan.gc.ca/climate-change/impacts-adaptations/climate-change-impacts-forests/carbon-accounting/carbon-budget-model/13107
Strenghts	Coherence with the GHG emission reporting of 4. LULUCF sector under UNFCCC and dedicated IPCC methodologies. Works with a daily time step and permits much more detailed budgeting of carbon pools.
Weaknesses	Its application is more demanding in terms of both input information and expert knowledge.

Source: CHMI

Collection and analysis of input data

The basic sources of data for compilation of greenhouse gases projections were the following documents:

1. National Greenhouse Gas Inventory of the Czech Republic, CHMI, Prague, April 2022.
2. MoE, 2017. National action plan on adaptation to climate change. Prague: Ministry of the Environment.
3. MoE, 2014. Waste Management Plan of the Czech Republic for the period 2015–2024, s.l.: Ministry of the Environment.
4. National Energy and Climate Plan of the Czech Republic, Ministry of Industry and Trade, 2019.
5. Documents provided by the Ministry of Industry and Trade, Ministry of the Environment, Ministry of Transport, Ministry of Agriculture, Ministry of Education Youth and Sports, Ministry of Culture, Czech Energy Agency, State Environmental Fund, Czech Statistical Office and CzechInvest.
6. Ministry of Industry and Trade, 2015. State Energy Policy of the Czech Republic
7. Ministry of Agriculture (2016). Ministry of Agriculture strategy with a view until 2030, no. 66699/2015-MZE-10051, 136 pp. (in Czech)
8. MIT. 2015: National Renewable Energy Action Plan of the Czech Republic. Ministry of Industry and Trade, 2015.
9. CHMI, 2021. Integrated reporting on greenhouse gas policies and measures and on projections in the Czech Republic. Czech hydrometeorological institute, 2021.

6. ESTIMATED VULNERABILITIES, CLIMATE CHANGE IMPACTS AND ADAPTATION MEASURES

This section builds on the previous 7th National Communication from 2017 and is based on the 2019 update of the Comprehensive Study of Climate Change Impacts, Vulnerabilities and Sources of Risk[19]. We first describe the data used, then the current and future trends in climate change in the Czech Republic. Next description of vulnerability in the Czech Republic is divided into water, agriculture, forestry, industry, transport, urbanized landscape, biodiversity, health and sanitation, tourism and emergencies.

6.1 Data and methods

We use RCP scenarios (Representative Concentration Pathways) for which the probability of their occurrence is not implicit. For most analyses, until about mid-century, the difference between RCP scenarios in the magnitude of expected impacts is not substantial, and significant and noticeable differences in estimated indicator values can only be reliably indicated for the second half of the century (see http://www.klimatickazmena.cz). Of the selected RCP scenarios, RCP2.6 is the closest relative representation of climate development under the Paris Agreement. However, its achievement is linked to a relatively major emissions reversal already by 2030, and real data do not yet indicate such a turn-around. On the other hand, in the short term, the development of emissions according to RCP8.5 cannot be ruled out and its inclusion was also driven by the ambition to show the benefit of mitigation measures also for impacts in the Czech Republic. However, as mitigation efforts continue, we believe that it is most realistic to expect the development of emissions according to the RCP4.5 scenario.

For the observed present-day climate change, the 1961-1990 normal is used, which was widely used till recently, and the climate was relatively stable during this period (the variables do not show significant upward or downward trends). However, this period is less suitable for assessing the state of the future climate, and it therefore seems more appropriate to make a comparison with the values measured over the most recent period of record, i.e. 1991-2020. The analysis of future climate is based on two data sources. Regional climate models have been used for most of the conclusions. For selected outputs, global climate models (GCMs) were also used to better indicate the possible dispersion of future developments.

The most recent regional climate models (RCMs) currently based on the CORDEX initiative (part of the WCRP, http://www.wcrp-climate.org/) are used to investigate future climate. The CORDEX project (http://wcrp-cordex.ipsl.jussieu.fr/) is currently the most important research in the field of regional modelling; the European part of the project is called EURO-CORDEX (www.euro-cordex.net). The results of the EURO-CORDEX regional modelling are used as

[19]https://www.mzp.cz/C1257458002F0DC7/cz/studie_dopadu_zmena_klimatu/$FILE/OEOK-Updated_Study_2019-20200128.pdf

inputs for the study of climate change and its impacts, including adaptation measures in both the IPCC Fifth and Sixth Assessment Reports. EURO-CORDEX uses new RCP emission scenarios and is based on simulations of global climate models CMIP5 up to 2100. GCM models were used for some of the outputs in this report. These GCM data were used as outputs for the six meteorological characteristics required for the CzechAdapt analyses (i.e., global radiation, maximum and minimum temperature, precipitation, wind speed, and relative humidity).

Statistically checked meteorological data from the Czech Hydrometeorological Institute (CHMI) were used to compare the outputs of the climate models. Each time series contains measurement errors, time series inhomogeneities and also missing values. In order to limit the influence of these problems on the results of the analysis, the selected time series were subjected to data quality control, their inhomogeneity was tested and any detected breaks in the time series were corrected. Finally, any missing data were filled in using interpolation methods. The processing was carried out in a daily step. The checked and homogenized data were then interpolated into grid layers with a resolution of 500x500 m using a custom interpolation method based on regression kriging. Elevation used as a predictor in the regression was smoothed in the case of rainfall and sunshine, while un-smoothed terrain was used for maximum, minimum air temperature, wind and humidity. Otherwise, for the so-called auxiliary predictors such as terrain roughness, slope and exposure, cooling was used for all the elements.

6.2 Climate change in the Czech Republic

The rate of observed temperature change in the Czech Republic expressed in trends over 10 years has increased. The scenario data are compared with the 1981-2010 normal, which is higher than the original 1961-1990 normal used in the 7. National Communication. This corresponds to lower estimates of temperature change. For precipitation, the signal of change is still ambiguous, with models currently projecting a slight increase in annual totals. Significant projected changes in extreme temperatures are reflected in the estimates of tropical and frost days.

6.2.1 Air temperature

Since the 1960s, a gradual increase in air temperatures has been observed, which has accelerated especially since the 1980s. As can be seen in Figure 6.1, the warmest period of all the selected periods is the last 15 years, i.e. the period between 2001 and 2016. During this period, the average air temperature for the Czech Republic was 8.4 °C. In contrast, the average air temperature for the Czech Republic in the normal period 1961-1990 was only 7.3 °C, a 1.1 °C lower value compared to the current situation. The greatest warming is observed mainly in large cities such as Prague and Brno, where the heat island of the city is also active (Figure 6.2).

Figure 6.1 Average air temperature in the Czech Republic for three selected periods (1961-1990, 1981-2010 and 2001-2016; top) and temperature trends for the whole period 1961-2016 (bottom)

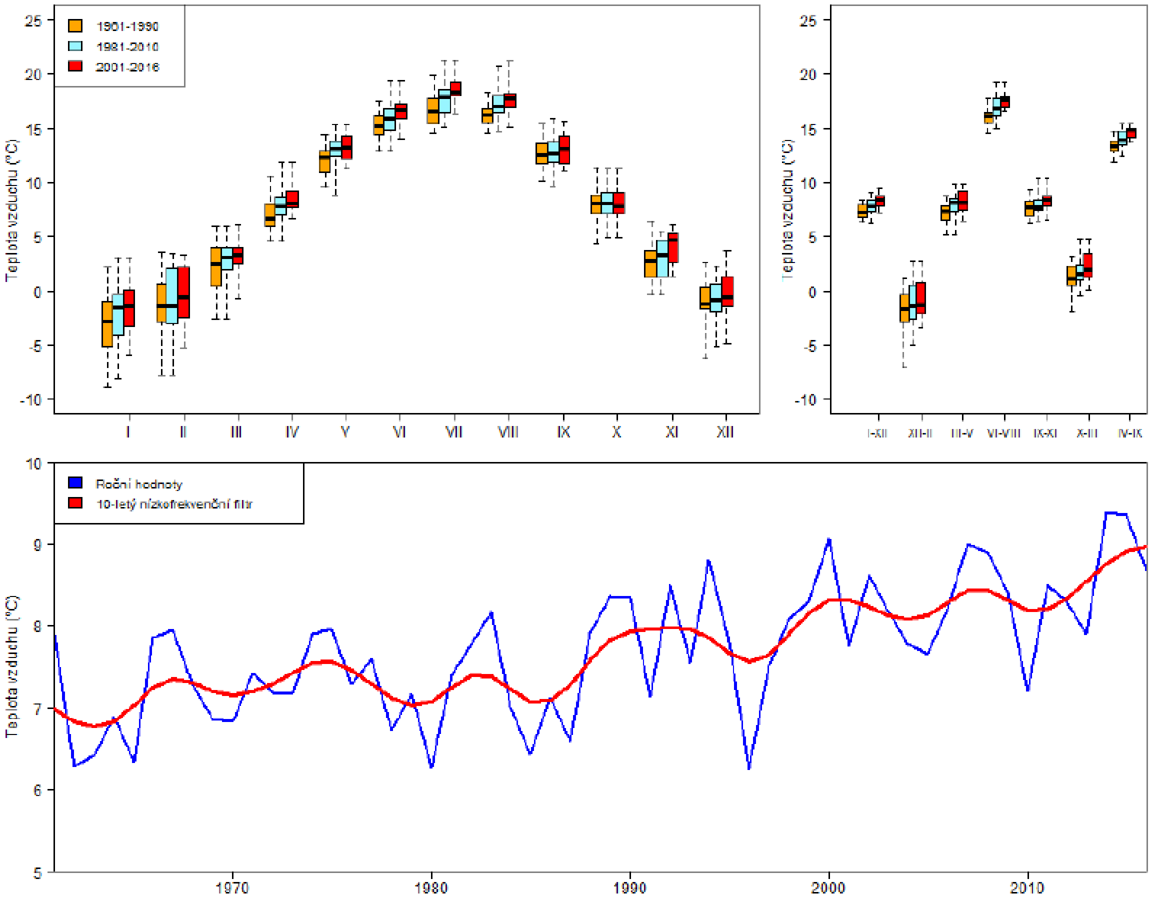
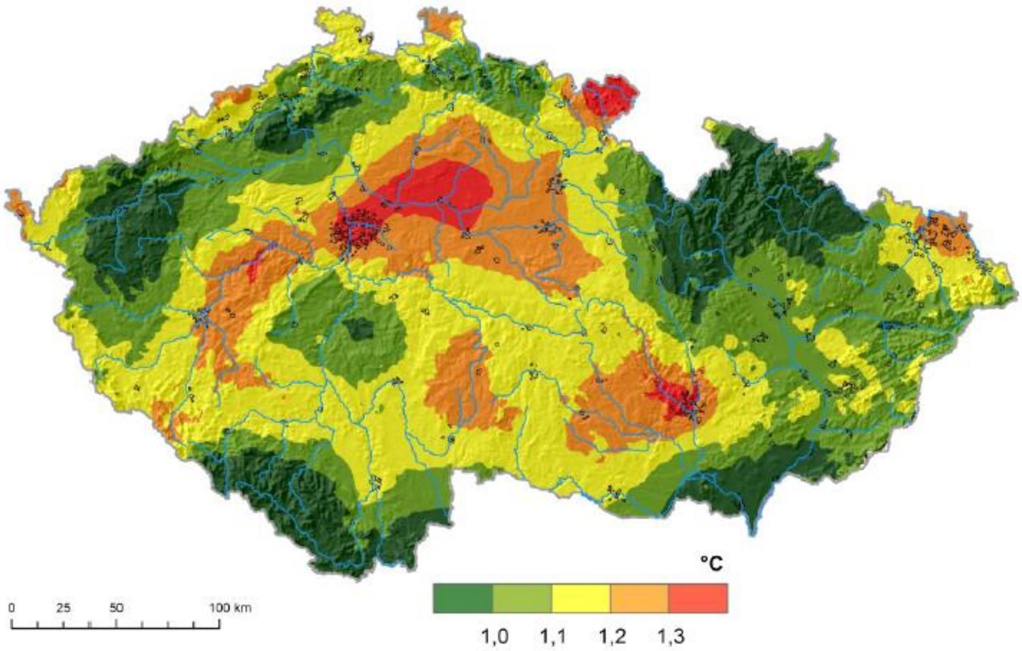


Figure 6.2 Deviation of average annual air temperature in 2001-2016 from the 1961-1990 normal



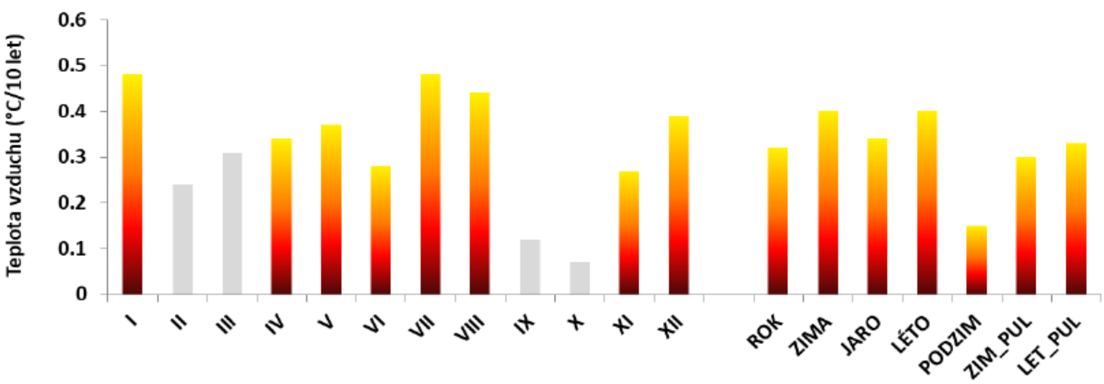
Air temperature increase for the period 1961-2016 is statistically significant in all seasons. A positive trend of 0.32 °C/10 years is observed for the annual values for the period 1961-2016 (Table 6.1). The warming is fastest in winter and summer (0.40 °C/10 years). In contrast, as can be seen in Figure 6.3, the smallest trend occurs in autumn (0.15 °C/10 years). A statistically significant trend is observed in individual months in January (0.48 °C/10 years), April (0.34 °C/10 years), May (0.37 °C/10 years), June (0.28 °C/10 years), July (0.48 °C/10 years), August (0.44 °C/10 years) and December (0.39 °C/10 years).

Table 6.1 Trends in average air temperature (°C/10 years), precipitation (mm/10 years), and number of tropical days (days/10 years) in the Czech Republic for the period 1961-2016 for each month, season and year

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Air temperature	0.48	0.24	0.31	0.34	0.37	0.28	0.48	0.44	0.12	0.07	0.27	0.39
Precipitation	2.55	0.00	1.31	–2.30	–0.95	–1.72	4.23	0.38	2.35	1.09	–1.05	–0.47
Number of tropical days	0.00	0.00	0.00	0.00	0.05	0.32	0.68	0.51	0.02	0.00	0.00	0.00

	Year	Winter	Spring	Summer	Autumn
Air temeprature	0.32	0.40	0.34	0.40	0.15
Precipitation	5.43	2.32	–1.93	2.89	2.39
Numberof tropical days	1.58	0.00	0.05	1.51	0.02

Figure 6.3 Linear trends of average air temperature (°C/10 years) in the Czech Republic for the period 1961-2016 (coloured bars correspond to temperature increases statistically significant at the p=0.05 significance level, on x axis starting from the left: the whole year, winter, spring, summer, autumn)



Based on all available experiments, annual air temperature in the Czech Republic will increase by 2.0 °C by the end of the 21st century (RCP4.5) or by 4.1 °C in the RCP8.5 scenario compared to the reference period (1981-2010). As shown in Figure 6.4, air temperature will increase at a similar rate until 2050 regardless of the emission scenario used. The temperature will be 1 °C higher in the period 2021-2040 compared to the period 1981-2010. After 2050 we see increasing differences between the emission scenarios. The temperature simulated by RCP8.5 increases sharply and, for example, the HadGEM2-ES RCA experiment projects a climate warming of 5 °C by the end of this century compared to the 1981-2010 reference period (Figure 6.5). In contrast, the RCP4.5 scenario from 2061 onwards points to a virtually stable climate with a warmer temperature of around 2 °C compared to the present. Under the RCP2.6 scenario, which assumes substantial success of mitigation measures and thus substantial and very rapid reductions in GHG emissions, we see a gradual stabilisation of the climate towards the end of the 21st century and a 'return' to the 1981-2010 temperature range. This analysis shows that by 2050 the changes that have been set in motion are virtually beyond our control. On the contrary, changing human behaviour will be absolutely crucial for climate development after 2050.

For each season (Figure 6.6 and Table 6.2), the most intense increase in average air temperature is projected to occur in winter. At the end of the 21st century, winter temperatures are projected to be 2.4-4.9 °C higher depending on the RCP scenario used. For other seasons, an increase in air temperatures between 1.7-3.8 °C is observed.

Figure 6.4 Evolution of annual air temperature for the Czech Republic according to the ensemble average of 11 RCM model realizations (smoothed with a 10-year low-pass filter)

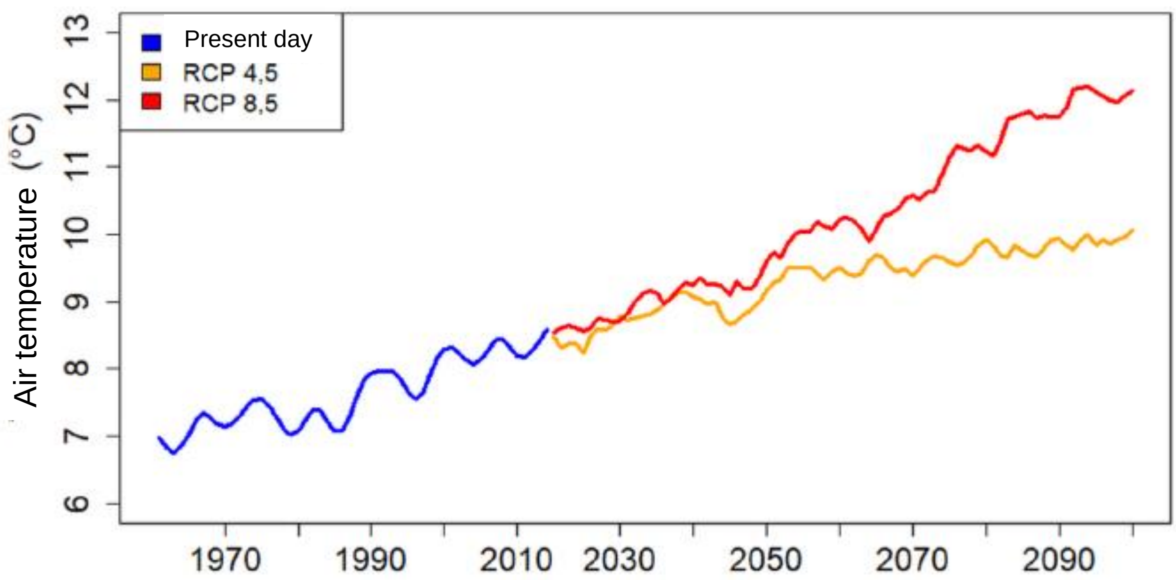


Figure 6.5 Air temperature difference (°C, on y axis in graphs) for the Czech Republic according to the ensemble average of 11 RCM model realizations for individual seasons (on x axis starting from the left: the whole year, winter, spring, summer, autumn) compared to the reference period 1981-2010 (RCP4.5 on the left, RCP8.6 on the right)

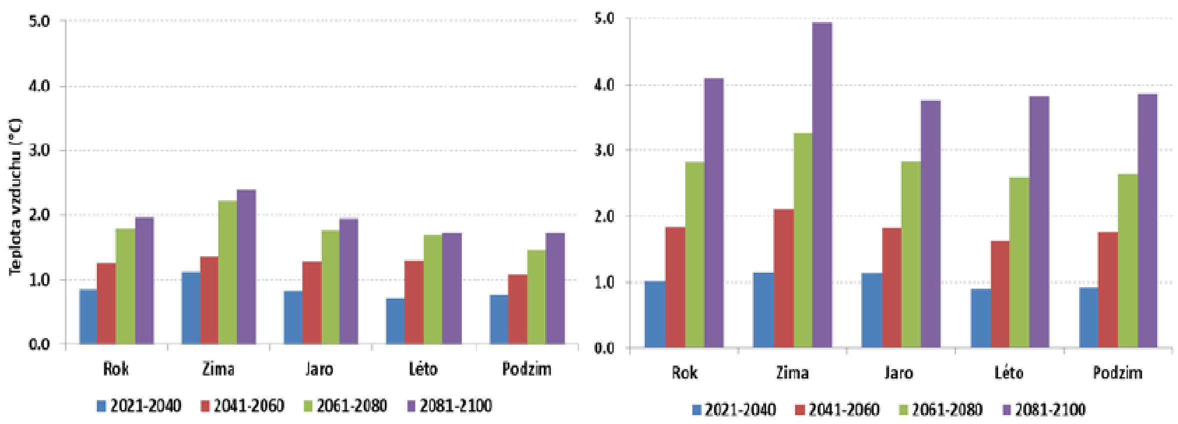


Figure 6.6 Difference in mean annual air temperatures in the future relative to the reference period (1981-2100) for the selected HadGEM2-ES-RCA model

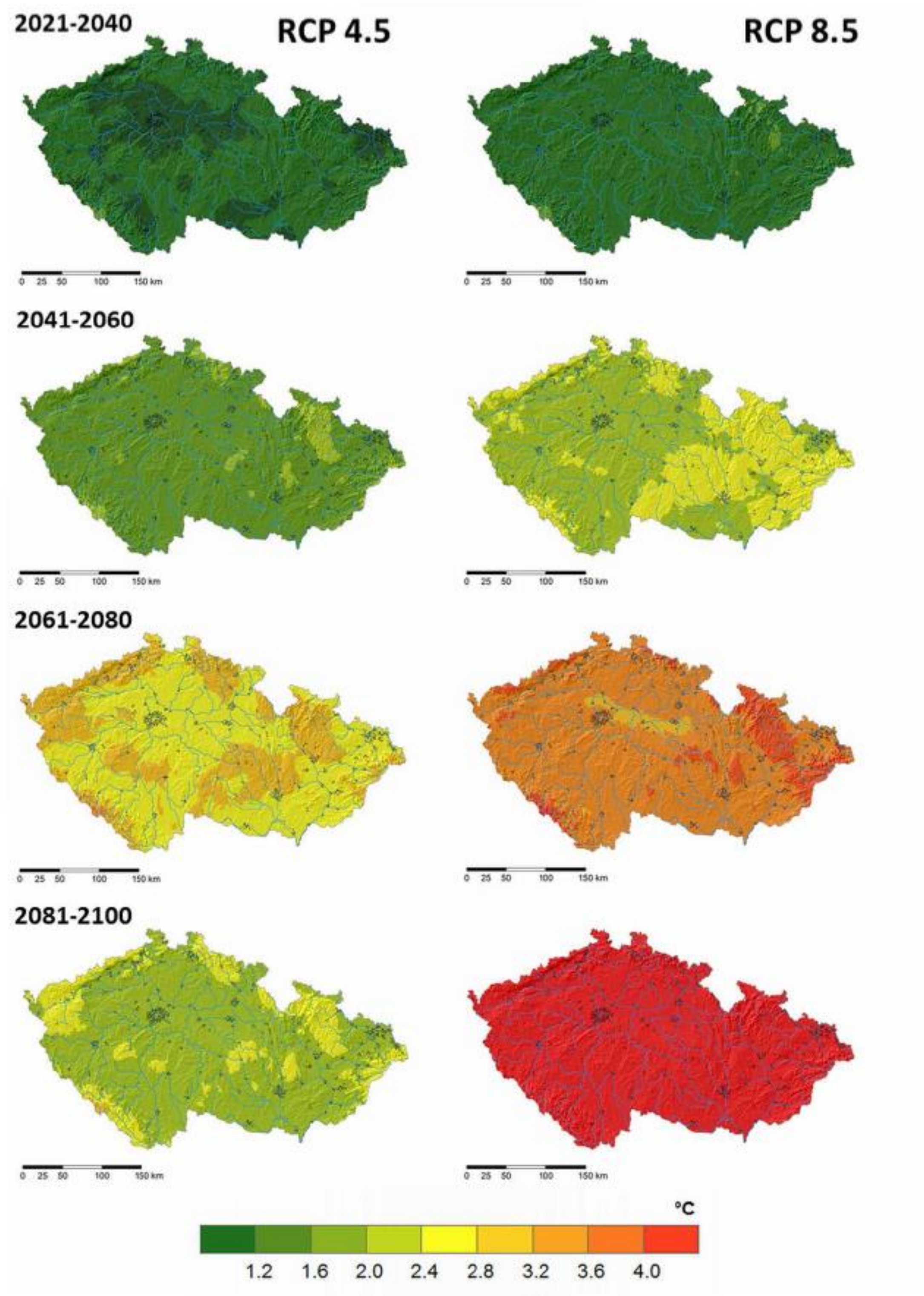


Table 6.2 Air temperature difference (°C) for the Czech Republic according to the ensemble average of 11 RCM model realizations for each period and season compared to the reference period 1981-2010

Emission scenario	Period	Year	Winter	Spring	Summer	Autumn
RCP4.5	**2021-2040**	0.9	1.1	0.8	0.7	0.8
	2041-2060	1.8	2.2	1.8	1.7	1.5
	2061-2080	1.8	2.2	1.8	1.7	1.5
	2081-2100	2.0	2.4	1.9	1.7	1.7
RCP8.5	**2021-2040**	1.0	1.1	1.1	0.9	0.9
	2041-2060	1.8	2.1	1.8	1.6	1.8
	2061-2080	2.8	3.3	2.8	2.6	2.6
	2081-2100	4.1	4.9	3.8	3.8	3.9

A more significant change will occur in the maximum and minimum air temperatures. The models predict that the highest increase in maximum air temperatures will occur in winter and the lowest in spring. Annual maximum temperatures will increase by 2.3 to 4.6 °C by the end of the century, depending on the RCP scenario. In winter, the outputs show an increase of 3.4-6.0 °C. Minimum temperatures are expected to increase even more sharply, particularly in winter (4.5 °C) and then spring (3.5 °C) for RCP4.5 and RCP8.5, respectively, with annual results similar to those for winter.

6.2.2 Precipitation

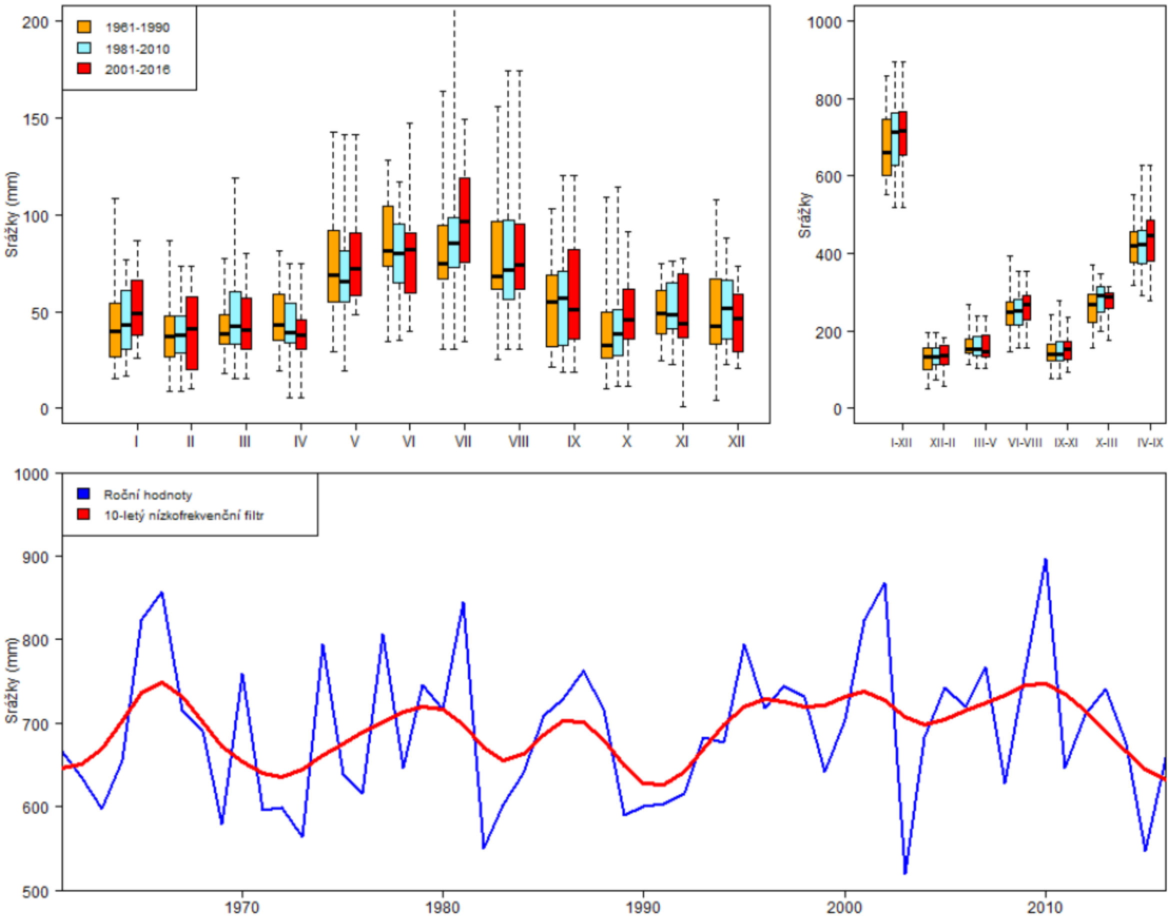
Precipitation in the Czech Republic is very variable. Dry and wet periods alternate significantly. This is the reason why precipitation does not show a statistically significant trend (Table 6.3). However, there is a change in the character of precipitation. We have a statistically significant increase in the number of days with higher rainfall totals, which are mostly due to storm activity in the summer months. In contrast, the number and length of episodes with little or no rain is increasing.

Tab. 6.3 Percentage of precipitation totals for the Czech Republic according to the ensemble average of 11 RCM model realizations for individual periods and seasons compared to the reference period 1981-2010

Emission scenario	Period	Year	Winter	Spring	Summer	Autumn
RCP4.5	**2021-2040**	106.6	109.3	105.9	105.0	107.4
	2041-2060	107.0	110.5	111.5	100.9	108.7
	2061-2080	110.3	115.9	115.1	104.4	109.5
	2081-2100	112.7	114.0	119.3	107.5	112.4
RCP8.5	**2021-2040**	106.5	110.6	109.3	103.4	106.2
	2041-2060	112.2	120.4	115.4	105.8	112.3
	2061-2080	113.7	126.1	118.7	104.3	113.8
	2081-2100	116.3	135.1	123.5	102.4	115.9

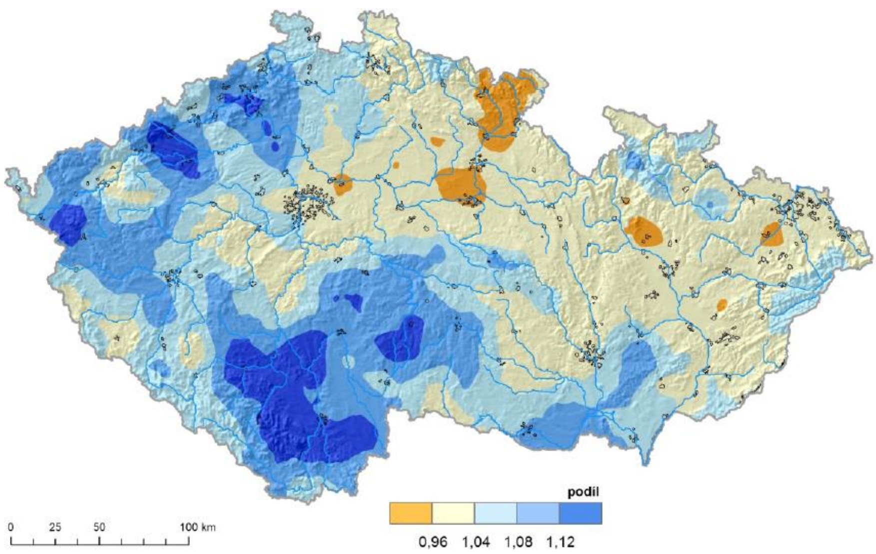
In the normal period 1961-1990, the average annual precipitation for the Czech Republic was 682 mm, which was lower than in the last 35 years (Figure 6.7). In the period 1981-2010, the average precipitation was measured at 703 mm and in the last 15 years (2001-2016) even 712 mm. This is not a statistically significant increase as there is a large fluctuation, which is characteristic of the climate of central Europe. Most precipitation falls in the summer months, mainly due to storm situations that result in higher runoff from the landscape. In contrast, the least rainfall occurs in winter. The least change occurs in the spring months, when rainfall is almost the same from season to season.

Figure. 6.7 Annual precipitation (on y axis) in the Czech Republic for three selected periods (1961-1990, 1981-2010 and 2001-2016; top) and precipitation trends for the whole period 1961-2016 (bottom)



The greatest change in precipitation occurred in southern Bohemia, where we observe an increase of over 10%. There was also an increase in precipitation in the west of the country. In the rest of the country, the changes are mostly up to 4% (Figure 6.8).

Fig. 6.8 Share of average annual precipitation in the 2001–2016 period compared to 1961–1990 normal



Precipitation predictions based on all 11 RCM experiments show a slight increase of 7-13% for RCP4.5 or 6-16% for RCP8.5. Higher precipitation is observed by the end of the 21st century (Figure 6.9). A statistically significant trend (8.3 mm/10 yr) was found for RCP4.5 for the period 2061-2100. Emission scenarios 8.5 show a statistically significant trend of 16 mm/10 yr for the period 2021-2060 and 13 mm/10 yr for the period 2061-2100. RCP2.6 projects an increase in precipitation only in the first period 2021-2060 (14.7 mm/10 years). The largest difference is seen in winter precipitation, which may increase up to 35% by the end of the 21st century (Figure 6.10 and Table 6.3). In contrast, the least change can be expected in summer precipitation.

Figure 6.9 Evolution of average annual precipitation (mm) for the Czech Republic according to the ensemble

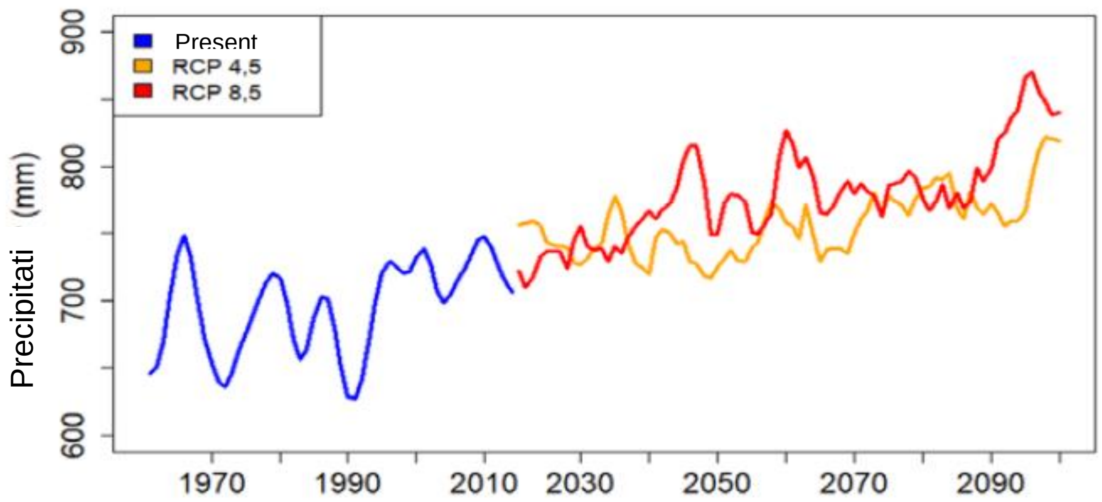
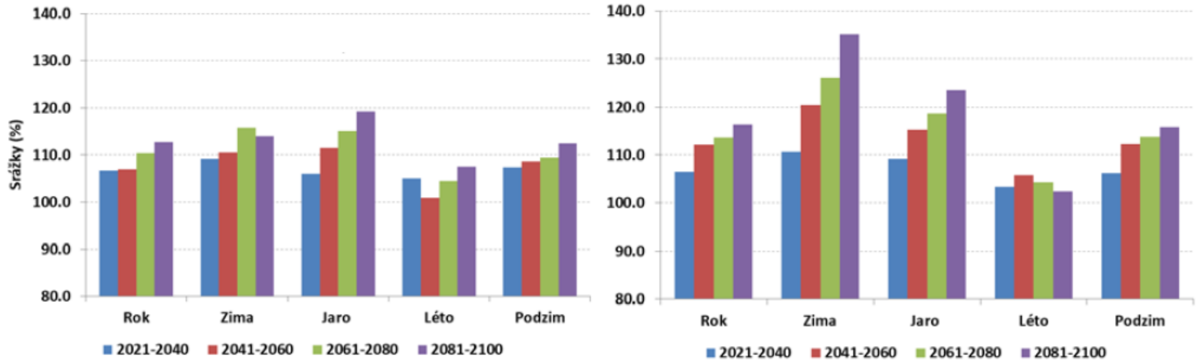
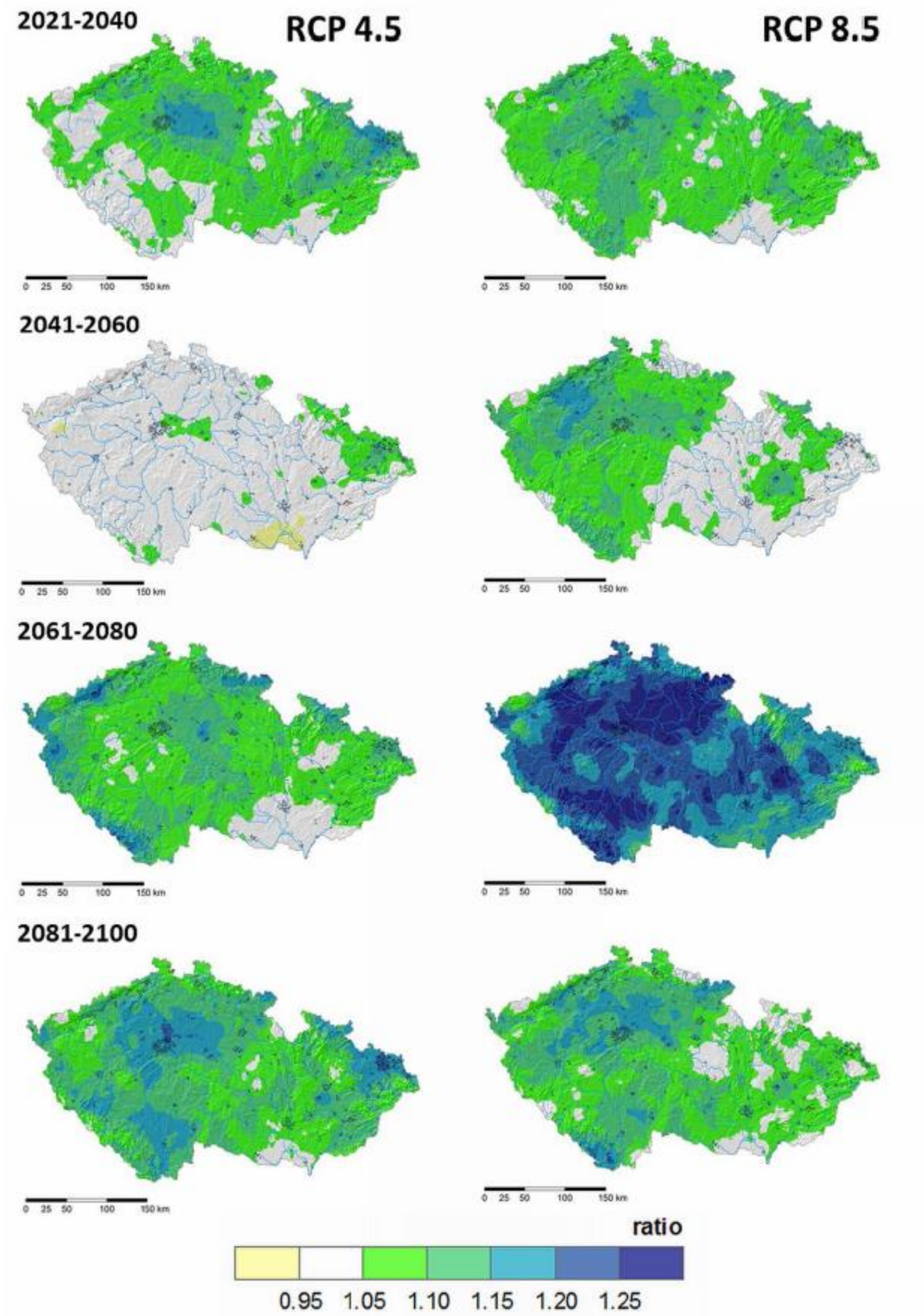


Figure 6.10 Percentage of precipitation (y axis) totals for the Czech Republic according to the ensemble average of 11 RCM model realizations for individual periods and seasons (x axis) compared to the reference period 1981-2010



As can be seen in Figure 6.11, changes in precipitation are not spatially consistent. The HadGEM2-ES RCA example shows that the smallest increase should occur in South Moravia, which is one of the most important agricultural areas. The differences between periods and emission scenarios are large. A significant difference can be observed between the periods 2041-2060 (RCP4.5) and 2061-2080 (RCP8.5). In the first case, similar precipitation totals are predicted as in the 1981-2010 reference period, but in the second case significantly higher precipitation values are modelled, by more than 20%.

Figure 6.11 Future mean annual precipitation relative to the reference period (1981-2100) for the selected HadGEM2-ES-RCA model



6.2.3 Climate indexes

Climate change is not only expressed in changes in basic climatological elements, but also in changes in special characteristics that are often more important for understanding change and setting adaptation measures. For this chapter, the number of tropical days was chosen as an indicator. Based on these, both the actual change and the estimated development will be described in more detail. Changes in other selected characteristics are described in summary tabular and graphical form.

Tropical days

A tropical day is a day when the maximum air temperature is 30 °C or more. This is a temperature extreme that usually already has negative effects on the landscape (increased evapotranspiration of plants, drying of the landscape) and on human health, especially when the corresponding conditions occur on several days in a row (so-called heat waves). Tropical days occur on average only a limited number of days per year for the whole country (on average 7 days per year during the period 1961-2016), but in recent years we observe a significant increase (Figures 6.12 and 6.13). For example, in 2015 and 2018, about 30 tropical days occurred on average across the country (spatially highly differentiated). During 1961-1990, only 4.4 tropical days per year were observed on average. In the period 1981-2010 there is already a significant increase of 70% to 7.6 days per year. In the most recent period, 2001-2016, an average of 10.7 tropical days per year was observed across the country, more than double the normal period.

Figure 6.12 Difference in the number of tropical days in 2001-2016 from the 1961-1990 normal

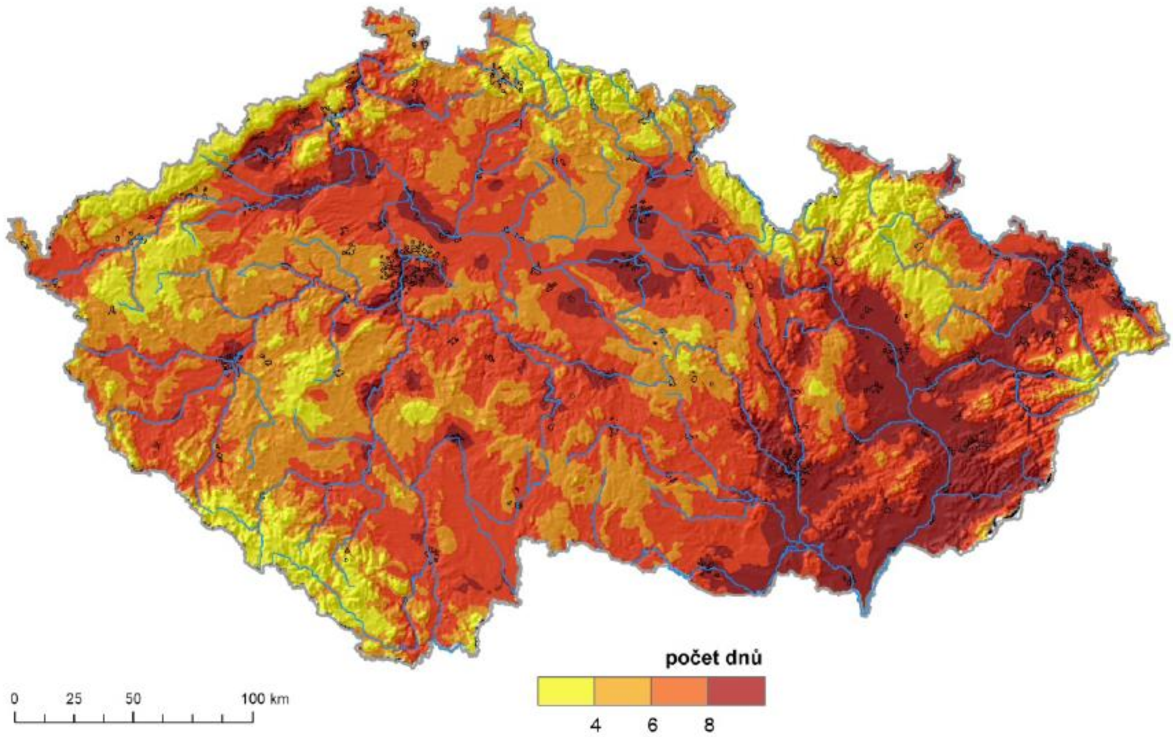
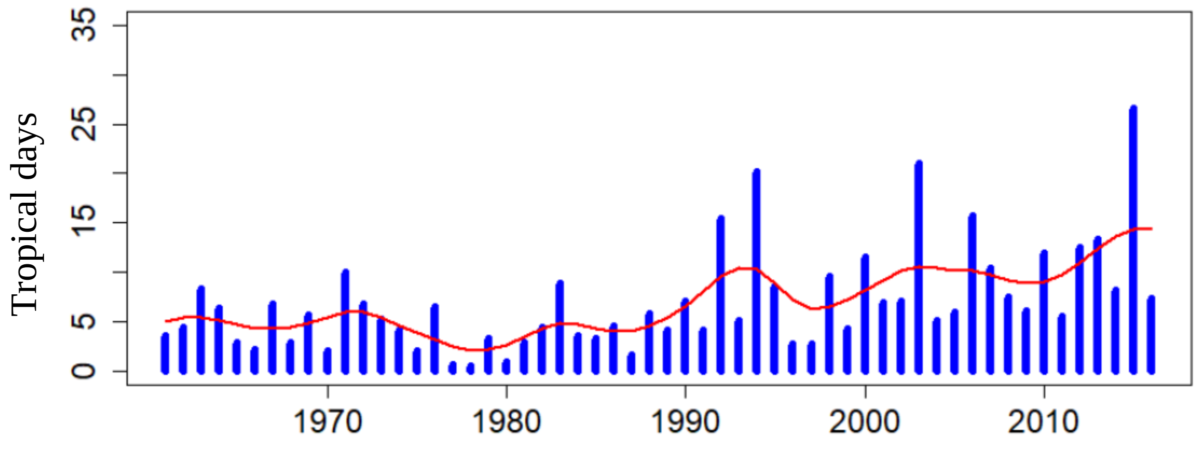


Figure 6.13 Average number of tropical days on the territory of the Czech Republic in 1961-2016 (area interpolation for the whole territory)



In the near future (2021-2040) there will be no significant increase in the number of tropical days (based on current model outputs). The values are consistent with the situation in recent years. A larger difference in model predictions and other emission scenarios is observed at the end of the century (period 1981-2100). The RCP4.5 emission scenario predicts twice the number of tropical days compared to the 1981-2010 period. RCP8.5 is even more pessimistic in this case. It predicts that the number of tropical days should increase to three to four times the current average (Figure 6.14). In practice, this would mean that the situations of 2015 and 2018 would be repeated virtually every year and would not be the exception.

Number of frost days and extreme temperatures

Another climatological index, which mainly characterises the conditions of the winter half of the year, is the number of frost days. In the current period, there is a statistically significant downward trend in the number of frost days, which will continue in the future (Figure 6.15). In the near future (2021-2040), the number of frost days decreases by 15% under both emission scenarios. By the end of the century, there would then be a decrease of 35% to 60% and in the most pessimistic scenario up to 70%.

Figure 6.14 Change in the number of tropical days (temperature 30 °C and above) relative to the reference period 1981-2010 calculated from three RCM models for the period 2021-2040 and 2081-2100

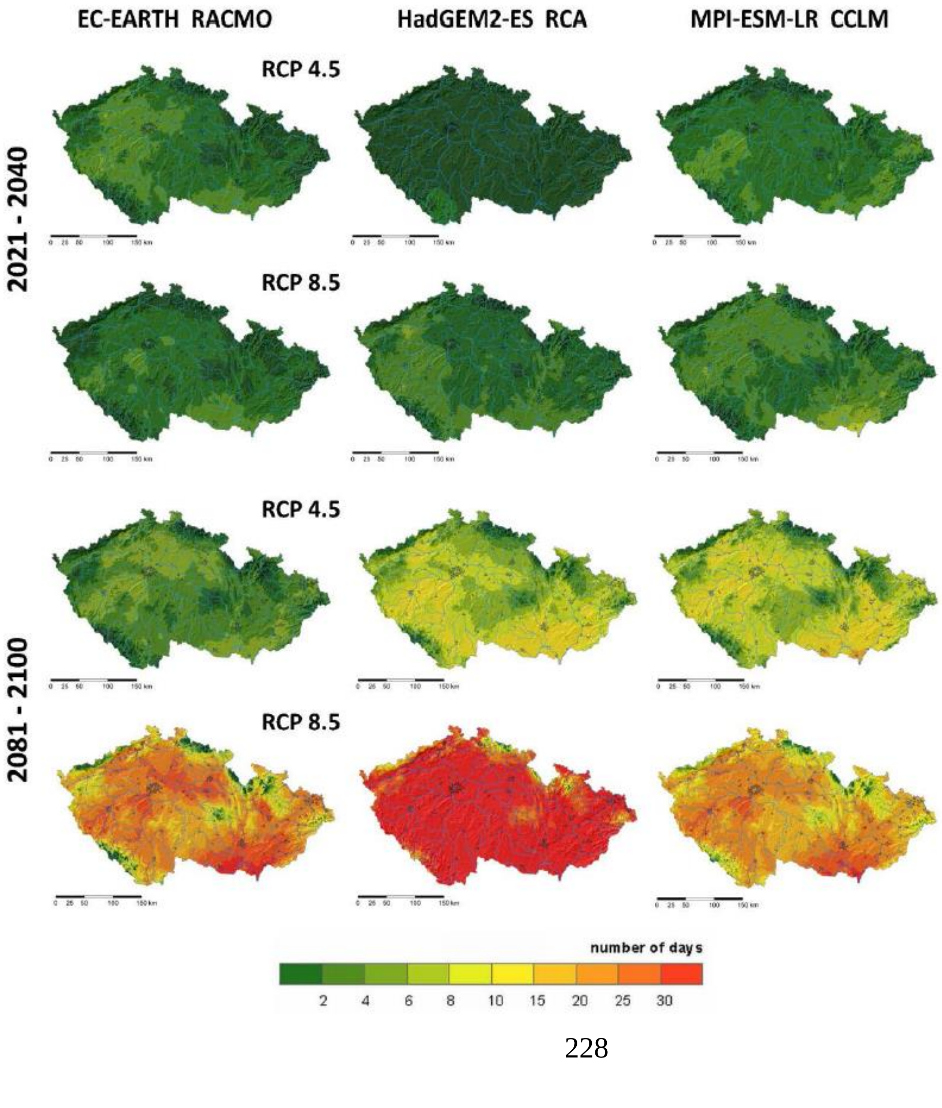
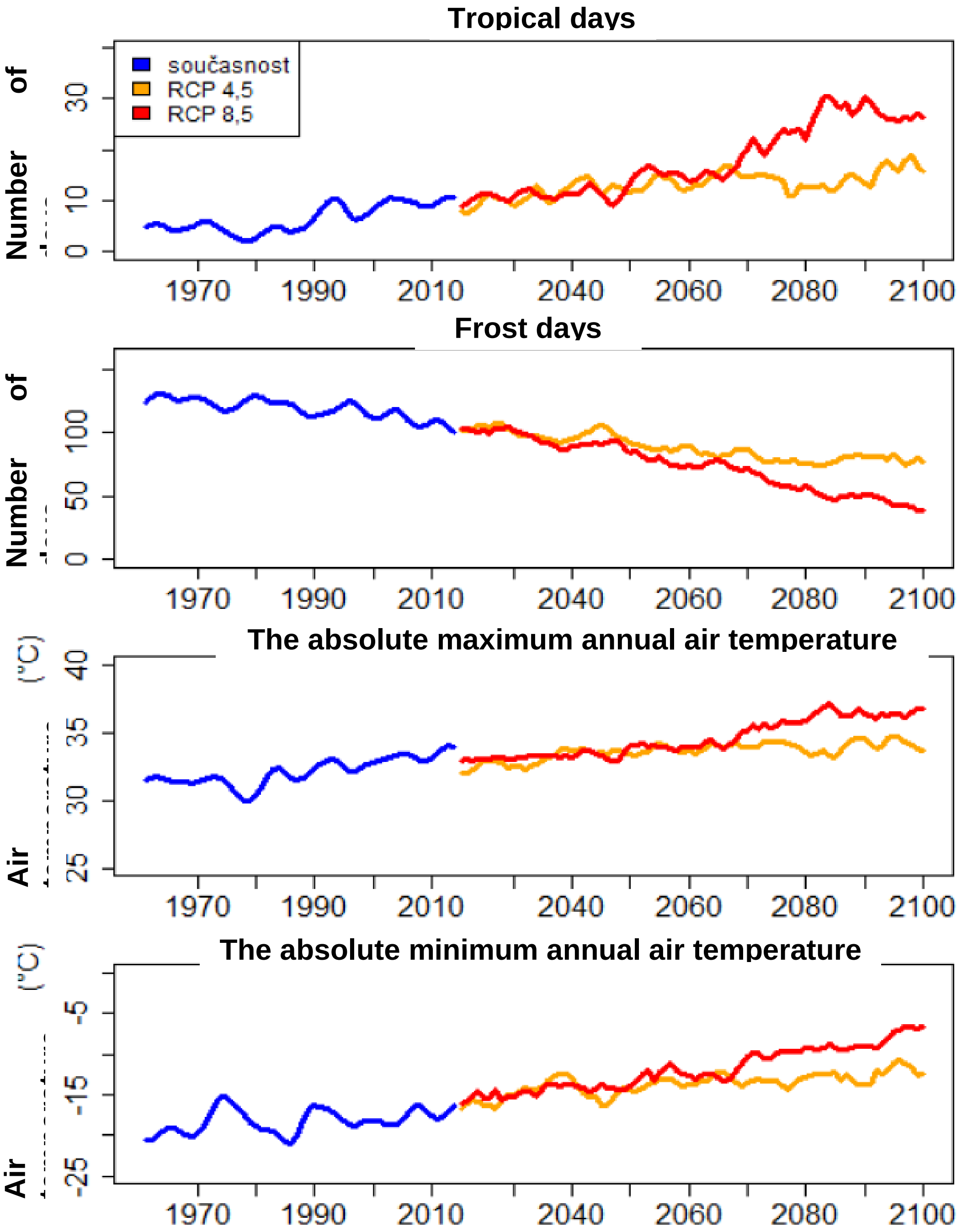


Figure 6.15 Trend of selected climatological temperature indices for the period 1961-2100, for the Czech Republic according to the ensemble average of 11 RCM model realizations (smoothed with a 10-year low-pass filter)

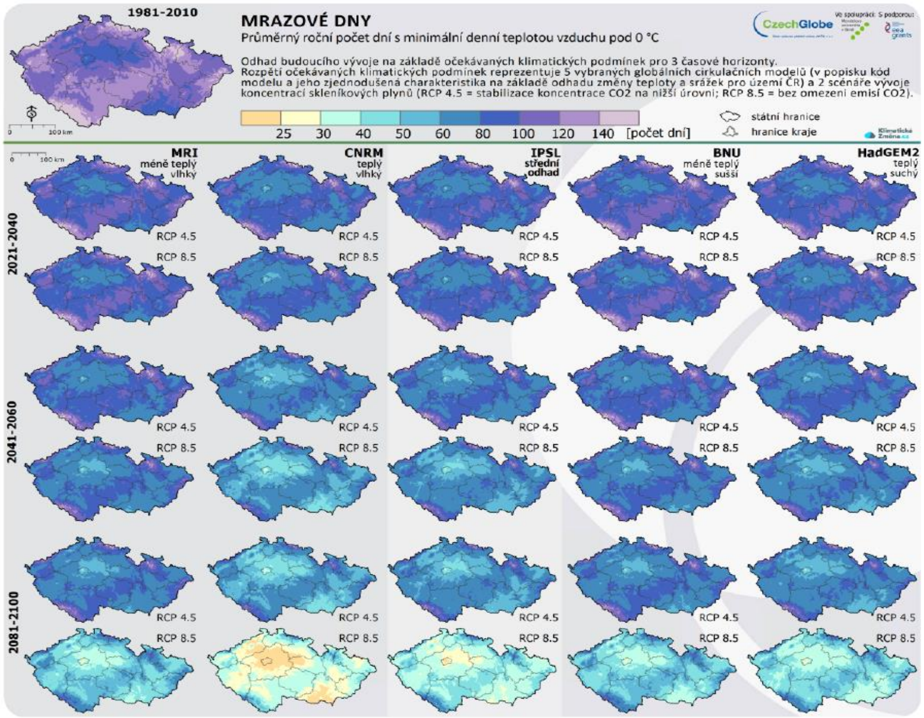


Both air temperature extremes should also change. Currently, the average annual maximum temperature for the Czech Republic is 32.5 °C. There will not be a significant increase between 2021 and 2040, but by the end of the century the temperature will be 1.3 to 3.9 °C higher (Tab. 6.4). In the least optimistic model outlook, the annual absolute maximum would rise to 38.3 °C (Figure 6.16). This would mean that values above 40 °C would be reached quite regularly at lower elevations. Extremely low temperatures should then moderate in winter. Currently, the average annual minimum temperature in the Czech Republic is -18.2 °C. This average should rise by almost 4 °C between 2021 and 2050, and by as much as 10 °C in the long term.

Tab. 6.4 Selected climatological characteristics (mean change - ensemble mean, minimum and maximum (range of all models) for the near term (2021-2040) and the long term (2081-2010), relative to the current climate (1981-2010), under two RCP4.5 and RCP8.5 emission scenarios. (TMA>=30 °C = number of tropical days; TMI<0 °C = number of frost days; TMA MAX = annual mean maximum air temperature; TMI MIN = annual mean minimum air temperature; SRA>X indicates the number of days with precipitation above the limit)

Index	**Scenario**	**2021-2040**			**2081-2100**		
1981-2010		**Median**	**Min**	**Max**	**Median**	**Min**	**Max**
TMA=>30 °C	RCP4.5	10.4	8.3	14.1	15.5	11.9	30.3
7.6 days	RCP8.5	10.5	8.7	14.9	27.4	20.0	40.6
TMI<0 °C	RCP4.5	99.0	88.1	104.2	77.7	70.2	94.1
116.6 days	RCP8.5	99.2	88.6	110.2	48.6	38.7	58.2
TMA MAX	RCP4.5	32.8	31.5	34.1	33.8	32.7	37.6
32.5 °C	RCP8.5	33.0	32.6	33.8	36.4	35.2	38.3
TMI MIN	RCP4.5	−14.6	−17.0	−12.5	−12.6	−15.0	−10.0
−18.2 °C	RCP8.5	−14.5	−17.1	−12.4	−8.9	−11.3	−5.7
SRA>0.1 mm	RCP4.5	114.8	111.1	118.4	114.6	111.4	121.6
112.5 days	RCP8.5	114.3	109.9	118.7	115.5	106.1	123.8
SRA>10 mm	RCP4.5	19.9	18.4	21.5	21.3	20.2	23.8
18.2 days	RCP8.5	19.8	18.4	21.5	23.0	21.5	24.7
SRA>20 mm	RCP4.5	5.2	4.8	5.7	6.0	5.5	7.0
4.8 days	RCP8.5	5.3	4.8	6.2	6.7	6.2	7.3
SRA>50 mm	RCP4.5	0.4	0.3	0.6	0.5	0.4	0.8
0.3 days	RCP8.5	0.4	0.3	0.7	0.6	0.4	0.9

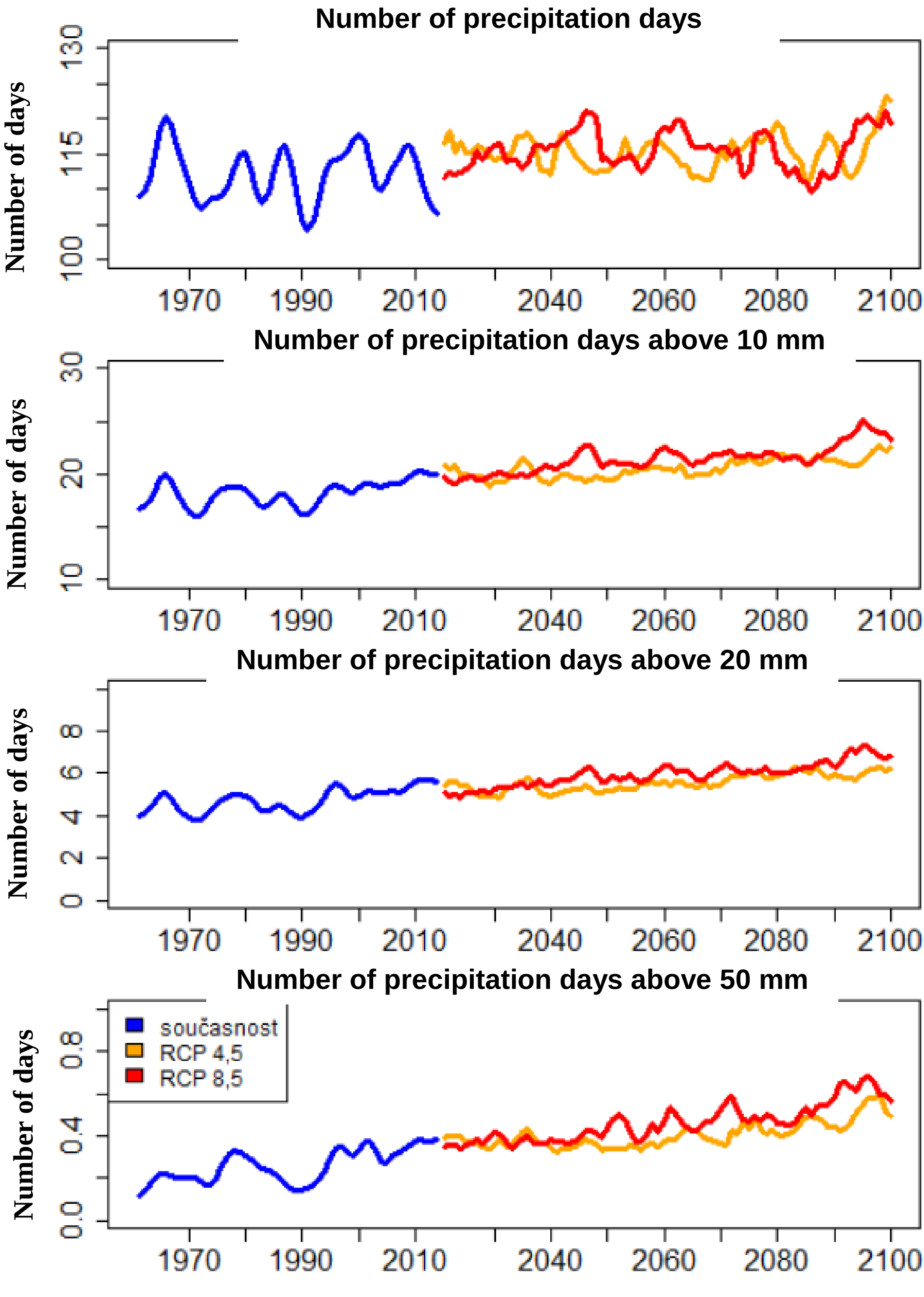
Fig. 6.16 Number of frost days projected by selected GCM models in 2021-2100 based on RCP4.5 and RCP8.5 (Source: www.klimatickazmena.cz)



Days with precipitation

Over the last decade, we have observed changes in the nature of precipitation in the Czech Republic, but without any change in the precipitation totals. We analysed the number of days with precipitation above 1, 10, 20 and 50 mm. No statistically significant trends were observed for the number of days with precipitation of 1 mm or more (at the p = 0.05 level), but for 10 mm, 20 mm or 50 mm we observed a positive statistically significant linear trend into the future (Figure 6.17). The increase in these intense precipitation events is primarily predicted by the RCP8.5 emission scenario. For example, the number of days with precipitation above 10 mm increases by about 0.6 days/10 years in RCP8.5 over the period 2021-2060 and by 0.5 days/10 years over the period 2061-2100.

Figure 6.17 Trends in selected precipitation climatological indices for the period 1961-2100, for the Czech Republic according to the ensemble average of 11 RCM model realizations (smoothed with a 10-year low-pass filter)



6.3 Vulnerability and adaptation

The following chapters describe in detail the impacts and associated vulnerability and adaptation options under the projected climate change scenarios in the relevant areas of interest. The analysis is mainly based on the scenarios described above.

In response to tackling the negative impacts of climate change and accelerating adaptation the European Commission adopted new EU strategy on adaptation to climate change in February 2021 (EU Adaptation Strategy). It builds on the previous strategy from 2013 and its evaluation from 2018. The Strategy aims at accelerating the process of adaptation to climate change, strengthening data collection and deepening cooperation with the financial and insurance sectors. It lays down framework and mechanisms, which should improve EU preparedness and enhance coordination of adaptation activities. The EU Adaptation Strategy also supports the EU Climate-ADAPT platform as an European-wide information system for climate change impacts and adaptation. It contains data, maps, information on adaptation projects, measures and other relevant information.

6.3.1 Water management

The negative impacts of climate change on water management can already be observed in some river basins in the Czech Republic in the form of a significant decline in runoff in the observed series since 1961. The cause of this negative phenomenon is the continuous increase in temperature leading to an increase in evapotranspiration, which has been compensated for by an increase in precipitation in most areas over the period 1990-2013; however, in some (still limited) areas this compensation has not been occurring in the long term. Low flows, reduced water flow speed, and increased water temperature will cause water to stay longer in rivers and reservoirs and to heat up more, which are generally the main reasons for the reduction in surface water quality. The expected changes in the hydrological cycle and water quality pose a risk of impairment of water management infrastructure and are likely to lead to increased abstraction demands. Increasing demands on water resources may lead to conflicts of interest between abstractors and with the interest of protecting aquatic ecosystems and ecosystems linked to the aquatic environment (MŽP 2015)[20].

The nature of possible changes in the hydrological balance in our area has been known for many years. It is based on projections of changes in the precipitation and air temperature regime for Europe, i.e. a gradual increase in temperature throughout the year and a decrease in summer, increase in winter and stagnation of annual precipitation (Christensen, 2007)[21]. Accurate assessment of the direct consequences of climate change on water regime changes is still burdened with uncertainties and regional differences (MŽP 2015). Modelled rising air

[20] MŽP, 2015. Strategie přizpůsobení se změně klimatu v podmínkách ČR, available online: www.mzp.cz/C1257458002F0DC7/cz/zmena_klimatu_adaptacni_strategie/$FILE/OEOK-Adaptacni_strategie-20151029.pdf.

[21] Christensen, J. H., et al., 2007. Regional Climate Projections. In: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, USA.

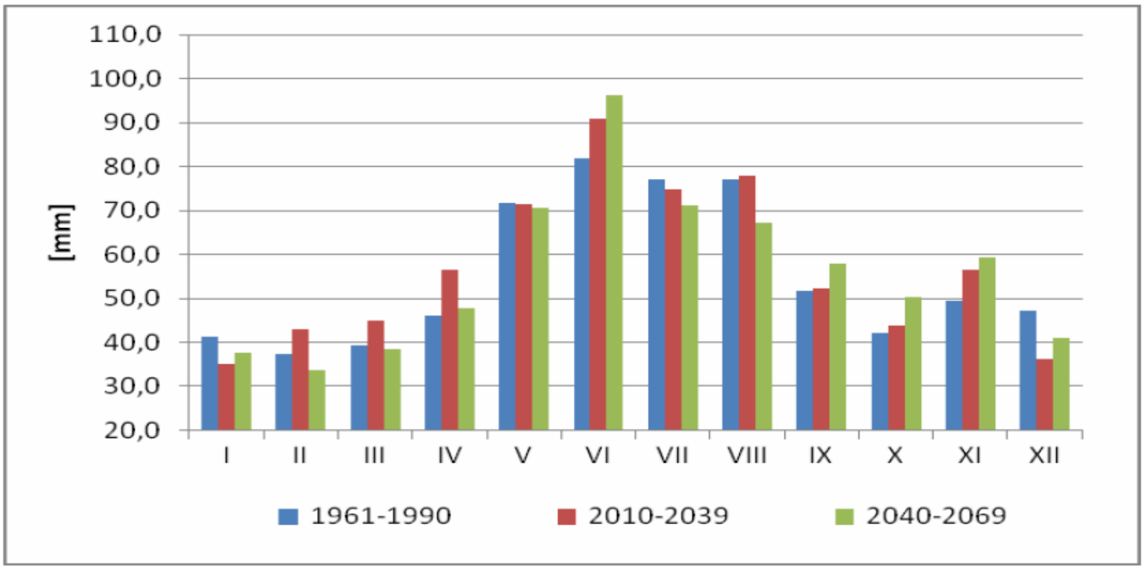
temperatures throughout the 21st century throughout the year will result in an increase in potential evapotranspiration, particularly between March and September (Table 6.5).

Table 6.5 Long-term monthly and annual totals of potential evapotranspiration of grassland [mm] in reference and scenario periods (MŽP 2015)

Period	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year
1961–1990	7	11	25	51	76	84	88	76	49	31	16	11	524
2010–2039	9	13	27	54	83	81	96	83	53	34	15	11	559
2040–2069	9	14	32	64	89	87	104	96	60	33	17	13	617
2070–2099	10	15	36	67	88	92	117	110	67	35	18	13	669

The modelled changes in precipitation are subject to significant uncertainty and there is no clear consensus between the models. The assumption of a change in the distribution of precipitation at different time horizons is shown in Figure 6.18. In contrast, Hanel et al (2011)[22], using the results of the ENSEMBLES project, suggests an increase in winter precipitation at the 2025, 2055 and 2085 time frames, but agrees with the work of Pretel (2011)[23] in the increase in spring and decrease in summer precipitation (Table 6.6). Higher decreases in summer precipitation are projected in the south and east of our area (mostly by 5-10%, even 15% in the east), but the spatial distribution of precipitation changes is unclear. Very similar results are also obtained from the EURO-CORDEX models used in the update of this study. The difference is in the positive trend of change even in summer and the overall larger increases in precipitation.

Figure 6.18 Average monthly precipitation in the Czech Republic in the reference period 1961-1990 and in the scenario periods 2010-2039 and 2040-2069 (Pretel 2011)



[22] Hanel, M., et al., 2011. Odhad dopadů klimatické změny na hydrologickou bilanci v ČR a možná adaptační opatření. Výzkumný ústav vodohospodářský T. G. Masaryka, v.v.i., Praha.

[23] Pretel, J., et al., 2011. Zpřesnění dosavadních odhadů dopadů klimatické změny v sektorech vodního hospodářství, zemědělství a lesnictví a návrhy adaptačních opatření. Technické shrnutí výsleků projektu VaV SP/1a6/108/07 v letech 2007–2011.

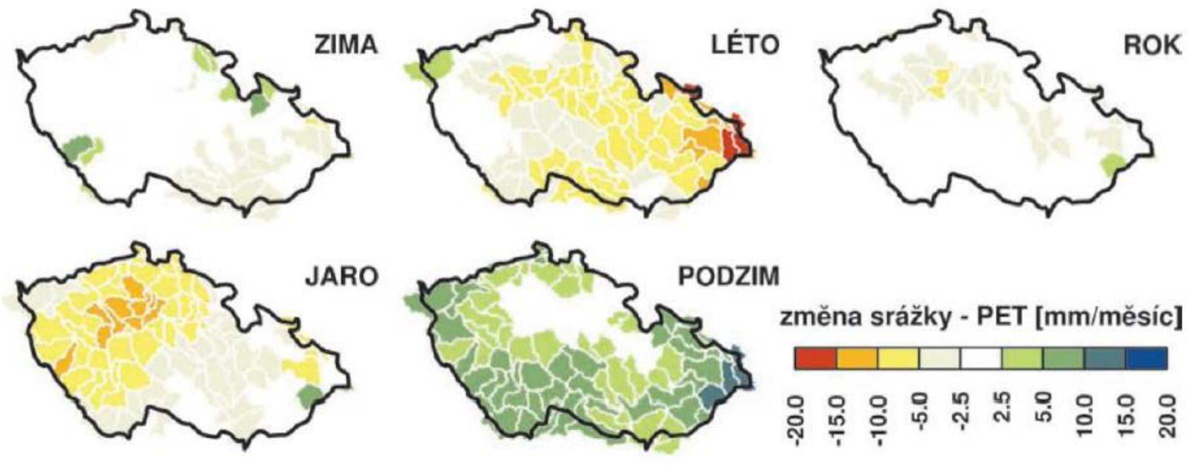
Available online: www.chmi.cz/files/portal/docs/meteo/ok/klimazmena/files/vav_TECHNICKE_SHRNUTI_2011.pdf.

Table 6.6 Average precipitation changes (%) for the Czech Republic in the ENSEMBLES and EURO-CORDEX climate model ensemble (Hanel et al 2011)

Precipitation	Winter	Spring	Summer	Autumn	Year
ENSEMBLES					
2025	4,83	1,32	2,79	5,75	3,35
2055	8,05	5,21	–1,9	6,19	3,94
2085	13,74	9,71	–6,61	7,51	5,49
EURO-CORDEX (RCP4.5)					
2021–2040	9,3	5,9	5,0	7,4	6,6
2041–2060	10,5	11,5	0,9	8,7	7,0
2061–2080	15,9	15,1	4,4	9,5	10,3
2081–2100	19,2	19,3	7,5	12,4	12,7

Predictions of future changes in the precipitation regime are highly uncertain. A more detailed analysis shows that the increase in total precipitation in the model results mainly consists of intense precipitation events with totals greater than 20 or 50 mm, while the total number of precipitation days remains unchanged. This would suggest an increase in the proportion of convective precipitation events (at the same time, the models predict a decrease in mean relative humidity in summer), so it is necessary to consider the findings of Svoboda et al. (2017)[24] of a large systematic bias of the models in simulating intense precipitation events. Hanel et al (2011) also report that the seasonal variation in precipitation and potential evapotranspiration changed differently in the 1981-2005 period compared to the 1961-1980 period. While in spring, there is a decrease of more than 5 mm per month in most of the Czech Republic, in summer the decrease is more pronounced in the eastern half of the territory, while in autumn an increase in this indicator is observed, Figure 6.19.

Figure 6.19 Change in evapotranspiration balance between 1961-1980 and 1981-2005 (top: winter, summer, the whole year; bottom: spring, autumn)



From the above-mentioned expected changes in climate parameters, potential changes in the hydrological regime can also be predicted. A shift of the spring maximum to an earlier date

[24] Svoboda, V., Hanel, M., Máca, P., Kyselý, J., 2017. Characteristics of rainfall events in regional climate model simulations for the Czech Republic. Hydrol. Earth Syst. Sci., 21, pp 963–980. doi: 10.5194/hess-21-963-2017.

can be expected due to less snow cover accumulation and earlier melting due to warmer air temperatures. At the same time, the decline in runoff and total water availability during the spring months would begin earlier. These two phenomena are also suggested by the results of the analysis of observed flows from 1961 to 2005 (Daňhelka et al 2013), which showed an increase in average flow in February and March (a shift of the runoff maximum especially in mountainous areas). On the contrary, a decrease in May and June (which can probably be attributed to increasing evapotranspiration). A similar regime shift would be observed for groundwater.

Overall, based on the observed hydrological data, it can be concluded that air temperature (influencing the magnitude of potential evapotranspiration) appears to be the dominant controlling factor for the emergence of significant trends in the runoff regime from our area for the time being. No trend changes have been detected in the case of precipitation, or they have not been sufficiently reflected in the hydrological variables.

In the case of the mechanism of climate change on the hydrological regime, several parallel processes with different outcomes can be identified:

- Increased temperature -> higher potential evapotranspiration -> lower average soil saturation.
- Longer rainfall-free periods -> lower average soil saturation.
- Higher precipitation extremes -> higher erosion potential and greater volume of water entering the runoff process at a higher rate.
- Increased winter temperature -> less snow pack formation -> less soil saturation and groundwater recharge.
- Lower average soil saturation before precipitation -> lower runoff coefficient during precipitation.
- Lower average soil saturation before precipitation -> greater soil water retention and less groundwater recharge during precipitation.

Regarding the future development of climate change impacts on the water regime, it can be stated that the projected changes in runoff are uncertain, but indicate an increase in winter runoff and rather a decrease in total runoff in other seasons. In terms of changes in the annual balance, runoff projections are uncertain even in the more distant future, but the probability of decreasing summer and autumn runoff increases significantly (Pretel, 2011). In terms of flooding, there is a significant change of opinion in new studies on the expected summer rainfall regime. In the scenarios available for the original study, a decrease in summer precipitation was considered as a very likely scenario, which was agreed upon by the vast majority of models developed before 2015, while in EURO-CORDEX an increase in summer precipitation is assumed. Given the generally problematic simulation of precipitation in climate models and the resulting inconsistency in the results of these simulations between generations of climate scenarios, it is advisable to respond to the resulting inconsistency with caution while being aware of the economic consequences. As the dynamics of the expected changes will increase over time, it may be recommended to validate the runoff scenarios in the coming years with a detailed focus on the conditions of the Czech Republic, applying correct methodologies for evaluating changes in the occurrence of extreme events. This issue is addressed by the PERUN project (TA ČR, SS02030040, Prediction, Evaluation and Research for Understanding

National sensitivity and impacts of drought and climate change for Czechia)[25] launched in 2020. The system is based on the ALADIN/CLIMATE-CZ model with a horizontal resolution of about 3 km. If specific flood protection measures are proposed or implemented, it is necessary to take into account their subsequent adjustments in the context of the current climate change scenario.

Part of the hydrological cycle is a directly related to the climate system, so changes in the parameters of the climatic elements are necessarily reflected in changes in the hydrological cycle. However, the propagation of changes is not linear, but is a complex of differently strong feedbacks between the atmosphere, hydrosphere and land surface. Changes in the hydrological regime have the effect of affecting the temporal and spatial distribution of freshwater resources, and the socio-economic activities and ecosystems that depend on them.

In theory, all elements of water quality and quantity under the Water Framework Directive are sensitive to climate change. In simple terms, climate change affects the following variables:

- Water availability (stream flow, standing water volume and groundwater supplies);
- water demand (especially at peak demand during dry periods);
- changes in design variables determining the management of water and other sensitive infrastructure;
- surface water quality, which includes temperature, nutrient content, pollutant content and intensity of degradation processes;
- the biodiversity of aquatic systems and terrestrial ecosystems linked to water;
- groundwater quality;
- how pollutants are mobilised in the soil and how they are decomposed and mobilised.

Selected national and European research activities provide only limited empirical data that would clearly indicate impacts, mainly due to the difficulty of identifying climate impacts from other impacts. On the other hand, there is much to suggest that freshwaters that are already affected by human activities may be highly vulnerable to the impacts of climate change and that climate change may, in the long term, significantly complicate attempts to restore the health of some water bodies or reduce the level of water security.

The Adaptation Strategy of the Czech Republic defines a wide range of adaptation measures, which can be divided according to their spatial application into:

- adaptation measures in the river basin (measures to ensure the stability of the water regime in the landscape, systems for managing and reusing rainwater, river basin plans and flood risk management plans, water supply and sewerage development plans, measures in water supply systems, measures in wastewater treatment plants and sewerage systems);
- adaptation measures on watercourses and floodplains (optimising the function of existing reservoirs and water management systems, rehabilitation of small reservoirs and increasing their reliability, modification of watercourses and floodplains, rationalisation of the water abstraction and discharge licensing system, protection of

[25] http://www.perun-klima.cz/indexENG.html

existing and prospective water sources, measures to infiltrate surface water into groundwater, water transfers, implementation of reservoirs in areas protected for surface water storage).

The most important adaptation measures from the perspective of the Czech Republic include reducing/slowing down surface runoff and promoting retention in the catchment area. This can be achieved, for example, by appropriate landscape design and the introduction of small reservoir and wetland systems. Another important group of measures are those that promote the collection and use of rainwater and water reuse in general. Such measures consist in particular in building decentralised systems for rainwater management, and in areas using groundwater, also in improving infiltration possibilities in urbanised areas by reducing the proportion of impermeable surfaces and building drainage systems with rainwater harvesting. In the Czech Republic, Macháč et al (2018)[26] attempted an economic assessment of specific implementation of nature-friendly measures in urbanised environments. Their results for different types of measures (urban greenery, wetlands, green roofs and walls, rainwater capture) show an overall positive economic balance of the measures in the long term if all co-benefits are included (e.g. impact on air quality, noise, carbon storage, increase in aesthetic value, etc.) and a comparative comparison considers the difference compared to the implementation of conventional solutions for new implementations. Flood protection systems are also related to the flood issue, consisting not only of technical infrastructure but also of nature-based measures, and include so-called 'soft measures', such as raising public awareness or developing crisis management. In the area of managing long-term drought and water scarcity, the above-mentioned measures to promote water retention in the landscape, optimising the function of existing reservoirs and water management systems, water transfers, the implementation of reservoirs in areas protected for surface water storage, and, in particular, legislative and financial instruments to encourage consumers to manage water resources more efficiently, are all relevant.

The cost-effectiveness of adaptation measures to secure water resources in the light of a changing climate is essential for the functioning of human society, as most other sectors (e.g. agriculture, energy and industry, health and sanitation) are interlinked with water management. Adaptation of the water regime and water management sector can therefore be clearly assessed as a priority, despite the costs that will have to be incurred.

6.3.2 Agriculture

Agriculture is probably the sector where climate change is currently having the greatest impact. It is key to food security and the combination of climate change and adaptive agriculture will significantly affect the level of ecosystem services in our landscapes. At the same time, agriculture is a sector with the potential to mitigate the impacts of climate change on other sectors and to carbon dioxide capture and reduce emissions of other greenhouse gases, particularly methane and nitrous oxides. The impacts of a changing climate in the agricultural sector are mainly connected to rising temperatures, which is also one of the main factors influencing changes in the water balance. In particular, the lowlands or regions formerly at the

[26] Macháč, J., Dubová, L., Louda, J., Vacková, A., 2018. Ekonomické hodnocení přírodě blízkých adaptačních opatření ve městech, Výsledky případových studií realizovaných opatření v ČR. IEEP UJEP, Ústí nad Labem.

very peak of productivity (i.e. the original beet and maize production areas) will be increasingly vulnerable to episodes of agricultural drought, with significant effects on the formation of the yield-forming elements of individual crops and consequently on the size and quality of yields. Their production potential will be permanently reduced compared to the cereal and fodder production areas. Higher temperatures will cause an earlier start to the growing season, which will increase the impact of spring frosts not only in the fruit and wine sector. In the event of warmer winters, water will not be stored in the snow but will run off, and in warmer winters more water will evaporate, which may result in incomplete spring saturation of the soil profile, leading to premature depletion of water by vegetation and a multiplication of drought caused by higher temperatures in the spring months. Another precursor to higher drought incidence will be the expected change in rainfall variability, with the number of rainfall days decreasing, especially in spring and summer, while the intensity of individual rainfall events increases. The risk of both wind and water erosion will increase and, in combination with drought, their damaging potential will also increase, as unused nutrients from mineral fertilisers will be readily carried away from the soil surface and there is a higher risk of pollution of watercourses as well as the air.

Changes in temperature and precipitation directly affect the conditions for farming, and if such changes are indeed occurring, there should also be a change in other climatic and agro-climatic characteristics, and in particular a response in natural and managed ecosystems. However, the issue of temperature and precipitation changes is more complex and varies from season to season. If we focus on the period from April to June, which is the key period in terms of yield formation for the vast majority of crops, we find that temperature and precipitation change even more than the annual average. This is reflected quite significantly in the dynamics of soil moisture, which is a key factor for agricultural production. One of the tools that can be used to illustrate changes in soil moisture is the use of so-called drought indices. When drought episodes are assessed on the basis of drought indices, there is a trend towards more frequent/intense drought episodes. However, due to the way the indices are calculated, it is very difficult to verify this trend using measured data. At the same time, the calculation of the drought indices does not fully take into account the site conditions (in particular soil type, terrain geomorphology and also vegetation cover dynamics). Therefore, in this chapter, soil moisture was used as an indicator of drought occurrence, calculated based on the procedure presented in Trnka et al (2014)[27], which incorporates all these factors (and many others) as much as possible. This method also confirms a decrease in the average surface water storage in the first half of the growing season by about 13% in the period 1961-2018, and this change is statistically significant ($p = 0.01$). It is therefore clear that the soil profile as a whole contains considerably less water in the period from April to June than it did in the 1960s, and this trend is very robust and is reflected over a large part of the territory. Conversely, in the second half of the growing season (July-September), no significant trend can be observed, as soil moisture becomes entirely dependent on actual rainfall patterns once reserves are depleted. The period from April to June shows a marked tendency towards higher inter-annual variability, especially in the case of the surface layer, particularly in the eastern part of the Czech Republic. The extent of the area affected by drought in a given season was on average 7% of the area in the

[27] Trnka, M., et al., 2014. Adverse weather conditions for European wheat production will become more frequent with climate change. Nature Climate Change 4, 7, pp 637-643.

1960s, while in the first decade of this century the size of the drought-affected area practically doubled and has significantly exceeded 15% since 2010.

Changes in climatic conditions are reflected in the water available in the soil during the growing season. However, we have not yet addressed the second effect of increasing temperatures, namely their effect on the onset, duration and timing of phenological phases. Indeed, if we accept as established fact that there is an increase in temperature, this trend must be reflected (and can be independently verified) in the onset and duration of phenological phases if they are examined over a sufficiently long period.

In general, a wide range of mechanisms and processes determining yield levels in crop production are being affected by a changing climate. There is a combination of both positive and negative influences, the proportion and importance of which will continue to evolve. Positive factors include, for example, the increasing level of atmospheric CO_2 concentration stimulating photosynthesis and leading to more efficient plant water use management. There is also the possibility of higher temperatures or a longer growing season. On the other hand, the negatives include a greater likelihood of drought occurrence and intensity, faster vegetation development (this translates into a shorter time to biomass formation in the case of existing varieties), a higher risk of stress from high temperatures during sensitive developmental stages, a higher risk of flooding or negatively affecting intense rainfall situations. We anticipate a change in average yield levels for winter wheat and spring barley, maize, rapeseed and other crops but primarily based on expected technological progress. The effect of higher CO_2 concentration will itself be reflected in better water management. In the case of arable forage and permanent grassland production, as well as longer maturing root crops (e.g. potatoes and beet), the possible lack of moisture in summer predicted by some models will have a negative impact and here too there is a question of potential yield reduction.

Furthermore, it is clear that the situation will vary from region to region, with adverse situations becoming more important in already dry and warm regions, while cooler regions will experience more favourable conditions. Thermophilic crops and varieties will be favoured. At the same time, an increase in vintages with dramatic drops in yields is predicted for the expected scenarios. Intercropping will not be a saving grace for the soil in some years due to water scarcity. These may cause a problem for the next target crop due to the soil moisture consumed. Nevertheless, their cultivation seems to be essential for restoring organic matter, stabilising the soil environment and field production. At higher altitudes, the average yield levels of the most important crops are expected to increase. The situation on individual plots will be influenced by the existing soil characteristics in terms of soil retention capacity, overall soil fertility or the nature of the terrain. The results of the above analyses are based on the assumption that soil quality will be maintained as it is at present. However, if the soil properties deteriorate, a negative impact on future yields can be expected. Restoration of soil structure, microbial environment and water retention capacity is and will be a key condition for the sustainability of agriculture. According to the data from VÚMOP, more than 50 % of arable land in the Czech Republic is threatened by severe to very severe erosion and about 40 % of soils are moderately to severely compact. The continuation of these processes in the context of climate change could have fatal consequences for Czech agriculture. Because of changes in soil moisture availability, stable production of permanent grassland will be problematic in some areas.

Recent studies have also shown that inter-annual variability in crop yields can be expected to increase due to increased frequency and intensity of adverse situations for crop production such as significant drought episodes, occurrence of high temperature stress at sensitive developmental stages, low temperature damage, etc. The analysis of yield variability between 2011 and 2018 alone has shown the crucial role of extreme weather. The question remains how significant disease and pest pressure will be, which are also not yet directly included for future yield forecasts. However, trends can be inferred based on the occurrence of more favourable conditions (including climate) for a given pathogen. Another unknown for the future is the characteristics of new varieties. Despite its limitations, modelling of future agro-climatic conditions undoubtedly plays an indispensable role in defining the most important expected risks to which research, development (including breeding activities - drought tolerance, resistance to high temperatures) and practice (e.g. use of local irrigation, increased representation of thermophilic crops - maize, sunflower, soybean) should respond.

The primary driver of the increased variability in production and its absolute level is the direct impact of extreme weather events (high temperatures and droughts, heavy rains, severe frost and other weather anomalies), which have increased in frequency in recent years as a result of a changing climate. Unfortunately, we are also observing a negative development of factors promoting soil erosion, which are further aggravating the situation. Increased protection of the agricultural and forest soil stock is crucial, as is the preservation of soil health, but even if the negative practices that degrade the quality of the soil stock can be reversed, we cannot a priori expect a substantial reduction in the level of yield variability. It is evident that the values of agro-meteorological production assumptions will change significantly, more so than we have seen in at least the last 200 years. Of the range of potential indicators that have been evaluated and presented in part above, the following have been selected as impact indicators:

- Effective growing season length, as an indicator of potential production;
- Surface soil moisture stress (0-40 cm), as an indicator of agricultural drought.

It is evident that there is a risk of reducing the potential productivity of key agricultural areas in the Czech Republic, as the effective length of the growing season is stagnating and possibly decreasing due to lack of moisture, primarily in the lowlands. Conversely, at higher altitudes with relative abundance of moisture, the value increases, but agricultural production at higher altitudes will not be able to make up for the shortfalls at lower altitudes in the long term. The resulting value of the indicator is quite sensitive to the choice of climate model, but a significant proportion of the models indicate a risk of productivity decline, a fact that has been neglected by some previous studies. Changes in the duration of snow cover are crucial and unfavourable for winter crop production. Although the short duration of the snow cover will allow some alternative practices to be applied, our territory remains vulnerable to extremely low temperatures during the winter months without snow cover. In general, the risk of drought will increase, in some scenarios by a factor of several times. This, in combination with the above changes, will undermine the production capacity of those regions that are currently in the maize and beet production area in particular. The number of extremely warm days will increase dramatically and the risk of negative impacts for crops, livestock and aquaculture is high. In addition, unlike moisture deficiency, the increase in the number of extremely warm days is not solvable for field crops by technical measures. The risk of days with maximum temperatures above 35 °C increases dramatically, as does the risk of high temperatures already in May.

The Adaptation Strategy recommends a range of adaptation measures to address the negative impacts of climate change on agriculture. While the emphasis is placed at the outset on flexible and sustainable land use, the introduction of new technologies and agricultural diversification, specific measures are then developed, with particular emphasis on maintaining soil fertility. In the case of maintaining the productive capacity of the territory, the adaptation strategy is much less specific. At the same time, the strategy does not address potential threats to production levels and, although it takes them into account and proposes 'diversification' of agricultural production and expansion of agricultural operators into other activities, the real risk of higher yield variability on the farming of these operators cannot be ignored. The measures proposed in the Adaptation Strategy cover many of the predicted impacts of climate change, but in some respects lack concrete (functional) proposals to ensure sustainable agricultural production.

The most important factor representing the primary economic impact of climate change on agriculture is crop losses due to both natural disasters and longer-term climate change. Agriculture as a sector is an essential element of national security and, particularly in the context of this sector; it should be borne in mind that its stability largely determines the functioning of society as a whole. Although the analysis focuses mainly on direct impacts, in the case of agriculture indirect impacts can be of staggering proportions.

In the case of agriculture, a focus on the sustainable management of natural resources, especially soil and water, will be a fundamental condition for effective adaptation. It is with this in mind that appropriate agronomic practices, agricultural technologies and crops need to be chosen.

Adaptation measures in agriculture include a range of interventions that can mitigate or eliminate the negative impacts of a changing climate. The different adaptations can be traced from changed soil properties, with the most resilient soils to climate change being soils with a black soil horizon, through to the adaptation of soil cultivation technologies. Another important point is the adaptation of crop structure and sowing practices and the use of breeding varieties resistant to adverse climatic conditions. Support for irrigation infrastructure is important in the Czech Republic. We must not forget economic adaptation measures and informative adaptation measures (i.e. raising awareness among stakeholders). Some of these measures are flexible and can be applied to a certain extent in the short term, as they are linked to decision-making and adaptation at the level of each farm within the seasons (e.g. species composition and crop rotation, volume of fertilisers and pesticides used, method of crop cultivation, use of intercrops). However, it is generally considered that adaptation planning in the agricultural sector is more of a longer-term issue, i.e. on a 10-20 year horizon. Where irrigation is an option, the necessary infrastructure (i.e. maintaining, rehabilitating or building new infrastructure) and the necessary water resources need to be in place. In the long term, only highly efficient irrigation methods are likely to be sustainable in suitable locations and for high value-added crops. The role of the state in these cases is primarily to use appropriate instruments to encourage farmers to put adaptation measures into practice. The conditions for this need to be created. Appropriate instruments may include the adoption of appropriate legislation, the dissemination of information and education for both farmers and consumers, investment in research and development, and various subsidies and financial incentives.

The appropriate measures in this case are, in particular, the timing of agronomic activities and the selection of appropriate varieties (the availability and use of new varieties must be sufficiently rapid) to make the most of the new climatic conditions. At the same time, it is more than desirable to focus on the most environmentally friendly farming methods that will support natural processes in agro-ecosystems while helping to improve soil quality, protect against erosion and promote water retention in the soil. Given that agriculture is a specific sector and most adaptation takes place at the level of individual farms, there is a need for potential risks and appropriate adaptation measures to be included in legislation and policies. In this sector, incorporating these aspects directly into a system of agri-environmental measures could be an effective way of developing adaptation measures and at an acceptable cost.

6.3.3 Forestry

The main impacts of climate change that pose risks to forestry are rising air temperatures, particularly spring and summer temperatures, decreasing summer precipitation and increased evapotranspiration. This leads to higher drought severity, increased frequency of dry periods and increased length of dry periods. This progression of meteorological factors is significantly weakening our current economic forests. The biotic agents, especially bark beetles, play a decisive role in tree mortality. Their increased activity is partly due to the weakened resistance of trees due to drought. For these reasons, they respond positively to ongoing climate change and can often spread rapidly. Increased incidence of storm winds may contribute to the disruption of declining forests. These phenomena create a number of risks for forestry, which currently threaten forest stands and will continue to affect them in the long term. Spruce is considered to be the most susceptible tree species in the Czech Republic, but pine also suffers from drought. The biotic insects currently pose a major risk to spruce and pine stands (mainly bark beetles), ash and alder (fungal pathogens). In general, the activation of insect pests of other tree species can also be expected. These changes are already manifesting themselves in the decline and even collapse of forest stands. The shift of forest vegetation stages (FVS), which are the basis of the system for differentiated forest management, is related to the increasing temperature. Today's areas of uplands and hills (mainly FVS 4-5) no longer meet the criteria corresponding to the ecological valence of the key tree species of Czech forestry, i.e. spruce. However, the shift in vegetation stages also affects stands of other tree species. However, the shifts in forest stages cannot be viewed mechanically: in addition to the 'average' meteorological values by which they are defined, the extremity of meteorological elements is also increasing.

When assessing the risks for growing forest trees at a local scale, soil conditions cannot be omitted, which significantly influence drought manifestations and tree resilience and can both amplify and weaken the effects of meteorological elements on the forest. We therefore observe and will continue to observe these changes with varying intensity, among other things due to the different conditions of the different sites. They confirm, almost without exception, earlier forecasts and differ from those predicted by the speed of onset, which is precisely linked to the recent occurrence of extreme seasons.

Negative factors that have been known for a long time have an impact on the health of forest stands. The abiotic factors are mainly wind, snow, drought, immission stress and nutritional deficiencies, while the biotic factors are mainly insects (bark beetles, leaf-eating insects, etc.), fungal pathogens, wildlife, small rodents and undesirable vegetation in the case of plantations and young stands. Significant decline of forest tree species continued in 2018 as a consequence of drought (high temperatures, unevenly distributed rainfall, e.g. www.intersucho.cz) during the growing season, the associated spread of various biotic insects, and also due to the effects of damaging winds. As a result of the bark beetle calamity, extensive clearings have been created in recent years. The incidence of dying pine trees, subsequently attacked by various biotic pests in the middle and lower elevations, remained high. In warmer areas, broadleaved stands have been attacked by folivorous insects and ash stands have experienced increased dieback.

In the Czech Republic, considerable resources are spent annually on preventing damage to forest stands by biotic harmful agents, which are concentrated mainly in the following areas:

- protection against unwanted vegetation in nurseries, plantations and crops;
- protection and defence against insects;
- defence against the harmful effects of game and small rodents.

A large proportion of this is for protection against damage to the forest by wildlife and against unwanted vegetation (mechanical and chemical suppression of buerena in nurseries and plantations). In recent years, a decisive share of resources has been spent on protection and defence against bark beetles.

Forestry is a rather problematic sector in terms of climate change, especially due to the extremely long (over 100 years) production period of forest stands. It follows logically that forests are being established or restored today that will reach production maturity in a completely different climate. The synergistic effect of extreme climatic fluctuations and anthropogenic influences, especially long-term immissions and management interventions, has resulted in a reduction in the vitality of forest stands in almost all of central Europe. Some key tree species are grown at or even beyond their current ecological tolerance limit. This is particularly the case for spruce, the dominant tree species in Czech forestry.

A related impact of climate change and the current decline in vegetation is an increase in fire risk. Forest fires are mainly associated with the arid regions of southern Europe and the Mediterranean, but severe drought and the accumulation of dry and highly flammable biomass and dead wood in forests also pose an increased risk to forest areas in central and northern Europe. In the Czech Republic, therefore, the fire risk is likely to increase in the coming years in areas where reforestation is not possible for technical or capacity reasons and where some dead wood remains untreated. It is well documented that in clearings without functional vegetation cover, there is a significant increase in surface temperatures, which increases the risk of fire.

In accordance with projected climate change scenarios, a shift in habitat conditions by at least two FVS is expected by the end of the 21st century. The changed habitat conditions will act as a predisposing stressor and predispose individual tree species and entire stands of forest trees to activate other, especially biotic, stressors. The proportion of spruce in the Czech Republic with poor health is estimated at 43-48 %.

For the current situation in forestry in the Czech Republic, the factors of sustainability of forest and forest management are crucial. Due to the current calamity with the formation of large clearings, indicators of the success of forest regeneration in these locations are specifically important. The above can be monitored using the following indicators (not including organisational capacity indicators):

- Ratio of total normal growth to total harvest

- Ratio of incidental to total harvest
- Area extent of clearings
- Average area of clearing
- Woody plant composition in the forest vegetation gradient
- Tree composition of regenerating stands in the forest vegetation gradient
- Volume proportion of standing dryland in stands
- Amount of standing dead wood
- Proportion of stands cultivated with non-pastoral management methods
- Proportion of natural and artificial forest regeneration.

The basic condition for effective adaptation of forest management to climate change phenomena will be a particular emphasis on the species composition of stands and natural regeneration of forests. Innovative approaches to reducing tree mortality include the promotion of mixed stands as opposed to monocultures and the introduction of resilience-building approaches. From the perspective of the Adaptation Strategy of the Czech Republic, the key measures appear to be primarily the use of natural processes and the cultivation of spatially and species diverse stands, as well as changing the preference of forest tree species and ecotypes, and stabilizing the amount of carbon fixed in forest ecosystems through the promotion of forest management with permanent soil cover. In addition, the strategy also mentions the importance of prioritising areas for implementing adaptation measures and protecting the genetic resources of forest tree species. From the state's point of view, these are mainly soft measures, which consist of adjusting forestry policies and legislation. They also offer the possibility of support through subsidy mechanisms. A sufficient level of education and dissemination of information on this issue will play a very important role. Given the long implementation and implementation horizons in this sector, it is essential to plan adaptation measures well in advance.

At present, it is necessary to reorient forestry production in the Czech Republic to other, more habitat suitable and resistant species. The shift towards growing spruce in mixed-species stands should significantly reduce the risk of spruce dieback (Neuner et al. 2015)[28]. Given the potential for increasing losses and mortality in existing stands, this is inevitable and, according to calculations based on data reported by Hanewinkel et al. (2013)[29], annual production losses of around 12.7 billion CZK are to be expected despite the adaptation of forest communities. The question is whether it is possible to mitigate these negative impacts by selecting sufficiently suitable and economically attractive species that could gradually replace spruce in our climatic conditions.

6.3.4 Industry

Services and business in the industrial and energy sectors (including chemical, mining, automotive and other types) in the Czech Republic are already and in the future will certainly be affected and threatened by the impacts of climate change, both directly and indirectly. The state administration and the business sector are quite aware of this, as is evident from the

[28] Neuner, S., Albrecht, A., Cullmann, D., Engels, F., Griess, V. C., Hahn, W. A., Knoke, T., et al., 2015. Survival of Norway spruce remains higher in mixed stands under a dryer and warmer climate. Global Change Biology, vol. 21(2), pp 935–946.

[29] Hanewinkel, M., Cullmann, D. A., Schelhaas, M. J., Naaburs, G. J., Zimmermann, N. E., 2013. Climate change may cause severe loss in the economic value of European forest land. Nature Climate Change, vol. 3, pp 203-207.

updated State Energy Policy (2015). A National Energy and Climate Plan was prepared in 2019.

Among the industrial sectors, the impact of climate change is particularly significant for the energy sector, as most stakeholders in this area are aware. Inevitable climate change creates clear challenges for the energy sector, which provides essential energy services that underpin quality of life and economic development. Improving the resilience of the energy sector to climate change is therefore vital for the economy, households and governments.

Climate change will cause three types of impacts on industry, related both to preventive action to avoid unwanted escalation of climate change and to the negative effects of climate change already occurring on businesses and services. The largest and most economically challenging is the necessary change in the structure and efficiency of industry in the face of anthropogenic climate impacts. This is mainly to meet the goals of the Paris Agreement and other policies requiring reductions in greenhouse gas emissions and resource depletion. This will require major changes in technology, a high degree of innovation and therefore high investment costs. The energy sector will be the most affected, as it is now seen not as an isolated energy sector but as an energy-environment sector. In terms of the impact of the changes that have already taken place, we are already experiencing threats to business continuity due to high temperatures, water shortages and extreme weather events (threats to operational capacity without physically endangering the energy installations themselves), but also direct impacts on businesses from natural disasters (accidents caused by natural phenomena). The risk of insufficient speed of adaptation to climate change, including the implementation of low-carbon energy and industry on a global scale, is significant, so that the Czech Republic and its industry and energy sector may be forced to respond differently after 2040 than is indicated in the current State Energy Policy (e.g. to invest in the construction of additional nuclear power plants with sufficient resilience to hydrometeorological extremes on an emergency basis, to introduce renewables rapidly, to respond with increased energy imports, etc.).) to ensure the level and quality of current and future services.

Because of too slow adaptation to climate change and a slow transition to low-carbon energy, the Czech Republic and its industry may lose its current (and future) competitiveness compared to neighbouring EU countries. Insufficient adaptation to changing climate conditions may also result in significant and prolonged blackouts, as well as NATECH (Natural Disasters Triggering Technological Hazards) accidents.

Industry and energy are key factors in the security of society. They provide irreplaceable services, but they are also a significant source of environmental threats, including a major contribution to anthropogenic impacts on climate change. Their role is thus not only significant but also complex and sometimes even ambivalent. The relationship between industry, particularly energy industry, and climate change is characterised by a complex system of feedbacks and interactions. In an oversimplification, industry is a source of wealth, but also of greenhouse gas emissions and other effects contributing to climate change, and is itself at risk from the climate change it helps to trigger. The complexity of the issue, together with the large number and diversity of stakeholders involved and the still limited knowledge, thus leads to inconsistent attitudes and a dynamically evolving knowledge base. This, together with society's value system, which is also evolving dramatically, is the basis for climate change adaptation policies and for building preparedness for potential environmental, technical and social crises, and it is natural that views and tools evolve rapidly.

Climate change creates clear challenges for the energy sector. In addition to the need to reduce emissions, the energy sector faces increasing risks from a range of climate change impacts that present a serious threat to energy security. While the energy sector is already taking a number of measures to mitigate short-term risks to energy supply (e.g. developing emergency response systems, diversifying energy sources and implementing energy and water efficiency measures), climate change is likely to exacerbate these risks in the short and long term. Climate change affects not only on the functioning of the energy sector and its actors, but also on society as a whole, which relies on the provision of energy services. This includes industry, commercial operations, hospitals, schools and other social services, as well as the individual households that rely on them. Increasing the resilience of the energy sector thus protects not only energy companies, but also the economies and populations that rely on energy services. A wide range of climate change impacts could affect the core components of the energy sector: generation, transformation, transport and storage, but also demand. These impacts vary by region, and the risks depend on the vulnerability of the area to physical exposure to hazards. Changes in climate and weather affect the physical nature and extraction of the energy resources on which the energy system fundamentally depends.

Industry and energy are some of the slowest adapting sectors due to the extremely high costs, time-consuming construction of sources and linear structures, and therefore the long implementation period of adaptation measures. However, energy is an important sector, the functioning of which is directly linked to the functionality of other sectors. In this chapter, resilience-enhancing measures are described in more detail, particularly in the energy sector.

In the Adaptation Strategy of the Czech Republic, adaptation measures for energy and industry focus mainly on improving risk management systems and developing existing safety measures. In the event of extreme hydrometeorological events (e.g. floods, storms, windstorms), maintaining the basic functionality of the energy sector (key infrastructure) is a priority. Other adaptation measures emphasise increasing the efficiency of water use in the production process, efficient waste management and recycling.

Adaptation measures in the area of electricity generation aim at ensuring sufficient generation potential of electricity sources and their diversification. They also aim at diversifying importers of key energy commodities that are not covered by domestic sources (oil and gas) and building up sufficient reserves in case of a collapse in their supply. The implementation of these adaptation measures is extremely demanding in terms of financial requirements for implementation, another problem is the long timeframe for actual implementation.

More research outputs and case studies than are currently available are needed for a robust evaluation of the expected impacts of climate change and associated adaptation measures. Within Europe, the focus so far has been on the impact of climate change on energy consumption rather than on energy production. This is also, why there is currently a lack of detailed information not only on appropriate adaptation measures but also on the costs of implementing them. Industry as such is a very diverse sector where private companies play a very crucial role, which of course significantly reduces the availability of data and therefore makes it impossible to quantify. In any case, the industry is very heavily dependent on energy supply, which is somewhat more scrutinised in relation to a changing climate. This is having a negative impact on the energy sector, particularly through high temperatures and heat waves, as well as more frequent extreme events.

Adaptation measures, such as the development of smart grids, a focus on decentralised electricity production and the promotion of green measures for residential and industrial cooling, can bring significant benefits, but their scale has not yet been monetarily quantified. As the energy sector is an absolutely essential component of a well-functioning national economy and is indispensable for all other sectors mentioned in this study, investing in appropriate adaptation measures will be an inevitable part of ensuring the security and prosperity of the country in the future.

6.3.5 Transport

The Czech Republic plays an important role as a transit country in both road and rail transport. In terms of lower transport performance and relatively small scale of infrastructure, air transport plays a less important role. Road transport is the most sensitive to climate change. The high density of the transport network, together with the surface materials of the transport infrastructure, are relatively vulnerable to damage, particularly from extreme temperatures and flooding. Roads also carry large numbers of people who are negatively affected by extreme hydrometeorological events. Rail transport is affected in the same way as road transport, but due to the different organisation of transport, the significantly less dense transport infrastructure and the different technology of its construction, the impacts of climate change are not as intense. For all modes of transport, extremes of precipitation represent the highest subjective risk. Extreme temperatures are more likely to affect passenger and driver comfort and cause less severe, though often more extensive, damage to transport infrastructure.

From a climate change perspective, the biggest problem remains the steady increase in the production of greenhouse gases, i.e. carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). Transport is therefore one of the factors contributing to climate change and part of the mitigation measures should therefore be aimed directly at reducing the negative impact of transport on the climate. Climate change can cause extreme weather events (torrential rain or snow storms, floods, storms, heat waves, etc.) which can have a negative impact on road, rail, air and water transport operations as well as on transport infrastructure. Another long-term phenomenon may be the negative impact of increased temperatures on transport structures, which may cause damage to them.

Due to the geographical location of the Czech Republic in the central part of Europe and its position in relation to major logistics centres and ports located in its territory, several transcontinental transport routes of a major nature meet:

- the central central European north-south route connecting ports on the northern Adriatic coast and ports in the Baltic Sea,
- the west-eastern route connecting the major logistics centres in Western Europe with those in Russia and Ukraine,
- a direction linking ports in the North Sea with ports in the Balkan Peninsula.

These facts make the territory of the Czech Republic one of the important transit territories within the expanding European Union. The projected impacts of climate change on the functioning of the transport network can be assessed on two basic scales. Firstly, in terms of the European context and, secondly, in the context of the impacts themselves, which are mainly manifested on the territory of the Czech Republic.

In the transport sector, the main economic impacts of climate change can be expected in the form of changes in the costs of maintaining, repairing and ensuring the functionality of infrastructure. In this sector in particular, some of the impacts are likely to be positive. An example would be a reduction in the costs needed to keep roads safe during the winter period. Of the indirect impacts, the impacts on public transport and the reliability of connections will be particularly significant.

An absolutely crucial point of adaptation of the transport sector is the implementation of efficient transport solutions that ensure smooth operation and flexibility of transport. At the same time, these measures can also contribute to adaptation in other sectors, particularly in the case of urban traffic flow, which can help to mitigate the problem to some extent during heat waves or urban heat islands. In contrast, structural measures are best applied to the construction of transport infrastructure as such. These include, for example, the use of appropriate materials and technologies in construction, taking into account the risks associated with a changing climate in the design of infrastructure and its immediate surroundings.

According to the Adaptation Strategy of the Czech Republic, the most important adaptation measures within the transport sector are good planning and ensuring the reliability and flexibility of the transport sector, which is also related to the ability to ensure operation and functionality after extreme weather events. In addition, a changing climate needs to be taken into account in the construction of transport infrastructure, particularly in relation to the selection of appropriate solutions for storm water drainage, resilience to temperature fluctuations, etc. This is also linked to the issue of appropriate shading of roads by vegetation, which can provide significant benefits for extremely stressed materials. Extreme temperatures are also linked to the issue of passenger comfort. Particularly during heat waves and extreme cold, it is essential to ensure an adequate level of cooling or heating.

Given that the main approach to adaptation in the transport sector will be better traffic management, especially on vulnerable and/or crowded sections, the question of economic cost is not entirely relevant in this case. First, the whole issue needs to be properly addressed through policies and legislation. The same is true for planning new infrastructure, where it is essential to consider climate change and to provide for adaptations from the very first stage of the project. As regards structural measures, these will need to be implemented not only in the case of new infrastructure, but also especially in the context of the reconstruction and repair of existing infrastructure.

In the transport sector, there are both negative and positive impacts of climate change on the expected future economic balance. In addition to the potential increase in infrastructure damage caused by both natural disasters and high summer temperatures or winter temperatures around zero (repeated thawing and freezing), a reduction in winter maintenance costs for infrastructure and travel can be expected. In addition to these items, however, it is necessary to add the costs of delayed services, replacement services and diversions, which together constitute a significant item. As there is not enough data and studies within the Czech Republic to assess more accurately the costs and benefits of climate change and adaptation measures, it is necessary to use examples from abroad.

6.3.6 Urbanised landscape

The main impacts of climate change in urban environments include increased temperatures, flooding and heavy rainfall and, in the future, water scarcity. Increasing temperatures will affect water circulation (quantity, quality) and the availability of water resources. Climate change is also likely to affect air conditions (humidity, quality), and some extreme events may become more frequent. This will have an impact on the population (health, well-being), buildings and public infrastructure (disruptions and failures of transport and technical infrastructure networks). A major anticipated manifestation of climate change in the urban environment is the further intensification of the urban heat island, especially in the absence of adaptation measures aimed at increasing evaporation from water and green features in cities. With expected further population growth in large cities, there may be greater exposure to the negative impacts of extreme hydrometeorological events, including floods, heavy rainfall and drought and water scarcity. Because of the above factors, socio-economic phenomena in society may be affected.

The urbanised landscape, i.e. the landscape of settlements, includes built-up areas including public spaces and areas of public greenery, industrial and logistics complexes and residential and recreational buildings, but also transport and technical infrastructure (network of roads, motorways and railways, navigation channels), water reservoirs and other areas transformed by human activity. The landscape of settlements is the landscape most significantly transformed by human activity. Within the Czech Republic, the settlement landscape is characterised primarily by a high population density, a high proportion of built-up area, a high proportion of paved and impermeable surfaces, a high concentration of economic activity and services (a high percentage of workplaces) and a high concentration of infrastructure (including networks). In addition, there is a trend towards a gradual increase in the size of the urbanised landscape. The high proportion of built-up areas affects the overall microclimate of the area and causes surface overheating, higher air temperatures, increased evaporation, rapid runoff of rainwater, dustiness, air pollution, etc.

The predicted climate change will have a significant impact on the climate of cities in the Czech Republic, especially in the context of the empirically documented regularity that cities form an urban heat island (UHI). UHI generates increased air temperature compared to rural environments. The main manifestations of climate change that have a particularly significant impact on cities and are sources of risk include:

- The length and frequency of heat waves due to the increasing frequency and magnitude of extreme air temperatures,
- the change in the frequency of flooding, and in particular urban flooding caused when the capacity of drainage systems is exceeded,
- the length of droughts potentially threatening water security.

Heat waves and flooding together represent the main risks of climate change for urbanised areas in the Czech Republic. In some areas, droughts and water scarcity add to these. In addition to heat waves and the urban heat island, flooding is another risk posed by climate change to Czech cities. Extreme events are expected to recur with increasing frequency. This will make cities located on rivers more vulnerable to flooding. Similarly, cities are expected to face more water scarcity and drought in the future.

Urbanised areas are already feeling the need to adapt, mainly due to the fact that they are centres of human settlement and at the same time are experiencing the impacts of climate change. Cities are particularly exposed to high temperatures, which are exacerbated by the urban heat island phenomenon. For this reason, it is important for local authorities to take action and adopt various adaptation measures that can mitigate the impact of heat waves on the quality of life of residents and their health.

Green infrastructure generally offers very good cost benefit ratio. In addition to the benefits associated with climate change adaptation, green infrastructure also provides many ecosystem services, which still significantly underestimates the potential and total benefits, especially in the longer term. These measures can of course be combined with traditional grey infrastructure to achieve a high degree of protection and sustainability, especially in the case of flood protection. It is imperative that cities include climate change adaptation in their strategic documents, whether in the adaptation strategy or in the spatial plan. The implementation of adaptation measures strengthens the resilience and preparedness of cities to climate change and related phenomena. However, the costs of these measures are highly individual and specific to the socio-economic, demographic and environmental conditions. In general, however, it is safe to say that green infrastructure is significantly less costly than grey infrastructure and offers a very attractive and effective alternative.

6.3.7 Biodiversity

In the last decade, environmental science has documented such significant changes in the geographic distribution of organisms due to global climate change that the "changing geography of life" on our planet is being discussed (Pecl et al 2017)[30]. The redistribution of biodiversity at the scale of the global ecosystem (biosphere) induced by climate change (so-called range shifts of species) affects human well-being both directly (e.g., through changes in food security and the spread of new pathogens) and indirectly (e.g., through ecosystem degradation). Documented global changes in the Earth's vegetation cover indicate unprecedented changes in the distribution of planetary biomes, completely unmatched by any other global ecosystem changes since the end of the last ice age (Gonzales et al. 2010)[31]. Climate-driven redistribution of biodiversity can lead to the establishment of new communities and consequently to rapid changes in ecosystem services. In the context of climate change, the ecosystem service of 'carbon sinks' is probably the most important of the ecosystem services. This ecosystem service is directly linked to the biodiversity of ecosystems.

In the Czech Republic, ecological research on the ability of ecosystems to fix atmospheric carbon has been carried out since 2005 in four types of ecosystems: mountain spruce forest, mountain meadow ecosystem, maize agroecosystem and wet meadow ecosystem. Fixing atmospheric carbon in vegetation and increasing the carbon content of soil organic matter is one of the potentially important ways to reduce the amount of greenhouse gases escaping into the atmosphere. Designing appropriate ecosystem management in terms of carbon cycle management (with the aim of carbon sequestration) requires detailed knowledge of the

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[30] Pecl, G. T., et al., 2017. Biodiversity redistribution under climate change: impacts on ecosystems and human well-being. Science, 355. doi: 10.1126/science.aai9214.

[31] Gonzales, P., Neilson, R. P., Lenihan, J. M., Drapek, R. J., 2010. Global patterns in the vulnerability of ecosystems to vegetation shift due to climate change. Global Ecology & Biogeography, 19, pp 755-768.

dynamics of carbon fluxes and quantification of carbon stocks at global, regional and local scales.

From these existing, but still preliminary, data on the importance of terrestrial ecosystems in the Czech Republic for carbon storage, several general key conclusions for the management of ecosystems in the landscape in the context of biodiversity conservation emerge:

- To promote carbon sink in forest ecosystems of the Czech Republic, striving to achieve the target tree species composition of management forests is a suitable strategy. From the point of view of the legitimate interests of forest owners, the target species composition of forests seems to be a suitable compromise between the current and natural state, which is not realistically achievable (it is not possible to have all forests of the Czech Republic in the form of forests). From the point of view of maintaining and restoring forest biodiversity, the target tree species composition in current management forests represents a significantly positive goal (Machar 2012)[32].
- For carbon sink in managed agroecosystems in agricultural landscapes, it is essential to maintain and, if possible, improve the amount of soil organic matter, which is only possible through agrotechnical measures that take into account the principles of good agricultural practice aimed at sustainable management of agricultural landscapes (Sluis et al 2016)[33].

As already indicated in the previous chapters of this study, dealing with detailed forest, agriculture and water management issues, most of the observed or predicted impacts of climate change on landscapes do not act in isolation and their synergistic effects cannot be assessed only in a "sectoral" manner. Large-scale clearings, resulting in some regions of the Czech Republic from widespread spruce mortality due to drought and because of bark beetle calamity, are the cause of ongoing biodiversity changes at local and regional scales.

The predicted trends of changes in climate conditions of vegetation stages will be reflected in the Czech Republic by a significant gradual improvement of conditions for xerothermophilic Pontic-Pannon biota, which will result in an increase in the area with climatic conditions of the 1st vegetation stage. This may result in a dramatic deterioration of growing conditions for some forest tree species, for example, the currently prevalent cultivation of spruce monocultures at lower altitudes will not be possible. Conversely, the extent of the area with conditions for upland boreal species, which are linked to a cooler and wetter climate, will be reduced, as the extent of the area with conditions of the 6th to 8th vegetation level will radically decrease (in the 2050 prediction horizon) and gradually even disappear altogether (2070 prediction horizon).

Due to the expected effects of climate change, a shift of ranges with an increased risk of extinction of species of conservation or economic importance can be predicted with high probability. Sometimes, however, range shifts may in turn increase the value of ecosystem services. Some biodiversity changes may affect ecosystem services directly. For example, the

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32 Machar, I., 2012. Protection of nature and landscapes in the Czech Republic Selected current issues and possibilities of their solution. In: Machar, I., Drobilová, L., eds., 2012. Ochrana přírody a krajiny v České republice, Vols I and II., Palacky University, Olomouc.

33 Sluis, T., Pedroli, B., Kristensen, S. B. P., Cosor, G. L., Pavlis, E., 2016. Changing land use intensity in Europe – Recent processes in selected case studies. Land Use Policy, 57:777-785.

expansion of species' distributions into new areas may lead to increased economic damage associated with insects, or conversely, species essential for the provision of key services such as pollination in agriculture may disappear. The occurrence of extreme weather events can lead to an increased frequency of forest fires, with impacts on forest ecosystem services such as carbon sink.

Adaptation measures may require actions such as relocation or reintroduction of endangered species or restoration of entire habitats and ecosystems. Estimates of the costs of ecosystem and biodiversity adaptation are based on the assumption that stand-alone adaptation will be insufficient and thus planned adaptation will be needed, but at the same time, there are strong synergies with existing biodiversity conservation and ecosystem restoration policies. Sustainable ecosystem management and the maintenance of ecosystem resilience are intended to provide cost-effective alternatives to technology-based measures. Aggregate estimates of the costs and benefits of adaptation measures for ecosystem services are not currently available. However, case studies suggest that investments in ecosystem and biodiversity conservation and ecosystem-based adaptation measures are cost-effective. However, any data related to adaptations for ecosystem services and biodiversity cannot be estimated at present, as the necessary data and analyses to generalise the case studies and apply them to the whole country are lacking.

6.3.8 Health and hygiene

Because of climate change, the population of the Czech Republic may be more exposed to some hazardous hydrometeorological phenomena and their impacts in terms of threats to life and health. Summer mortality is likely to increase due to the occurrence of heat waves. The elderly and socially excluded population, including young children, are likely to be most at risk. Preventive measures will need to specifically address the population from socially excluded areas. Increased mortality during heat waves will particularly affect populations outside hospitals or other facilities (vulnerable populations without social supervision), and outreach health and social services will need to be strengthened. At the same time, the resilience of the population is increasing over time, with younger age groups no longer affected by mortality due to high temperatures. A positive effect of climate change is the reduction in cold-related mortality. There will be an increase in hospital admissions and deterioration in the health of populations with chronic diseases of all age groups due to heat waves.

Conditions for the proliferation of pathogens in natural waters and food will be created. There will be a need for stricter sanitary surveillance, including testing for contamination of raw materials and products by food and drinking water producers, which does not leave water and food safety solely to the goodwill and goodwill of the producer. There is the possibility of increased diarrhoeal disease associated with temperature-insecure diets. Prevention means focusing attention on the appropriate technical design of water and sewage systems, on early identification of the causative agent, and on prompt solutions. The risk of transmission of digestive diseases may also be related to the quality of water in wells. After large-scale flooding, when the area remains flooded, conditions will be suitable for the spread of tropical mosquitoes, ticks and other insects that transmit infections in the domestic environment. The situation should be under control, including monitoring for insects. In 2018, the emergence of tropical disease due to domestic infections has been recorded in the country. One person died from West Nile fever, which is transmitted by "domestic" mosquito Culex pipiens. Attention must also be paid to migratory birds carrying out long-distance transmission of parasites.

Drought is putting drinking water sources at risk. Water conservation and unnecessary use of drinking water must be addressed. In some areas, groundwater sources are already drying up and the situation is being addressed with new or replacement storage in the locality. There are contributing conditions, such as strip mining, deforestation, soil compaction and other practices that devastate the soil so that rainfall is not absorbed and drinking water sources are not recharged. Groundwater quality is mostly unsatisfactory due to pesticide content. The National Institute of Health has estimated the health risk from drinking water with atrazine as low, but unless new water treatment is implemented, the uptake of pesticides through drinking water may persist.

All populations are vulnerable to the health impacts of climate change - but some groups are more so. Stronger impacts will be found for young children, the elderly and those dependent on social or health care or chronically sick. Where people live is a very important characteristic. People living in mountain areas and cities are vulnerable to climate change for different reasons (WHO, 2009). Climate change is a long-term process and we can assume that there has already been adaptation due to natural resilience (resilience) due to the impact of information availability, access to care and social contacts. The impact on health is related to:

- heat waves, frost days, weather changes,
- forest fires and associated air pollution,
- floods,
- landslides and rockfall,
- shortage of drinking water,
- contamination of drinking water with chemicals (pesticides, chlorination products from eutrophication),
- loss of productivity, loss of employment in poor areas (very highly reliable),
- food and drinking waterborne diseases (highly reliable) related to poor food and water hygiene,
- deterioration in the quality of surface water used for bathing,
- air pollution and related diseases, (pollen, mineral component, pesticides, traffic, ozone and ultrafine particles.

The entire population of the Czech Republic is vulnerable to climate change. In particular, changes in temperature, both in annual averages and in extreme temperatures in summer, represent a widespread factor with significant impacts. The size of the population and the size of vulnerable groups play a role. More generally, climate change affects major social and environmental determinants of health, such as the availability and quality of drinking water, ecosystems, agriculture and food production, economic development and migration. Climate change affects the basic conditions that humans, like any other animal, need to live - safety, a microclimate adequate for their thermoregulation, the quality and sufficiency of drinking water, the quality and sufficiency of food, the presence of biological determinants of their health, and air pollution in the form of aerosol particles and secondary ozone. In general, the elderly or sick people are most at risk. Geographically, the most affected population in our conditions are mainly inhabitants of large cities, i.e. the majority of the population of the Czech Republic. This is due to the construction of cities and the high concentration of solid surfaces, which cause the so-called heat island of the city, which amplifies the effects of high temperatures even more. In general, the larger the size of the city, the higher the heat island of the city. Living in blocks of flats increases the risk. In addition, the more vulnerable and socially excluded sections of the population are often found in inner cities. In some cities, there are even more such population groups. However, the impact of high temperatures on mortality and hospitalisation can be expected throughout the Czech Republic.

The following groups are particularly vulnerable to climate change:

- people with undeveloped or altered thermoregulation (seniors, children),
- chronically ill people (circulatory and heart diseases, respiratory diseases, musculoskeletal diseases, endocrine diseases, mental and nervous diseases, disabled people),
- people living in socially excluded areas, single people,
- immigrants who do not know the Czech environment, realities and language,
- certain professions, carried out in an outdoor environment, carried out in an indoor environment without air conditioning,
- people living in an area where medical care is not available.

The economic analysis of climate change impacts on health and sanitation focuses on the assessment of health effects. In order to determine the total value of these impacts, it is important to consider primarily health care costs, opportunity costs and negative benefit costs (PESETA 2014)[34]. Climate change can have both negative and positive effects on human health. For example, milder or warmer winters may contribute to a decrease in deaths related to cold temperatures. In addition, a reduction in the number of illnesses caused by classical air pollutants due to their lower concentrations in the air caused by lower consumption of fossil fuels for heating. In contrast, the increased frequency and intensity of summer tropical days and heat waves can result in increased morbidity. Those most susceptible to heat extremes are young children, the sick and the elderly, who currently make up a large proportion of the Czech population.

The issue of population vulnerability is very broad and mainly individual, so it also includes a large range of different adaptation measures. It is precisely because of the high diversity that it is most appropriate to choose systematic solutions, such as raising awareness and informing the population or various health care programmes that can help prevent deaths and help people prepare for climate change-related events. However, this requires the health sector to change its current approach to responding to the impacts of climate change on human health and to become proactive, incorporating climate change issues into its activities and informing the population about the potential risks and, above all, how to protect themselves. The Adaptation Strategy of the Czech Republic identifies two groups of measures in the field of health and hygiene with a link to new diseases related to climate change:

- Measures to reduce the incidence or eliminate infectious and non-communicable diseases (define and specify risk areas, ensure quality diagnosis and treatment),
- Awareness measures (preventive awareness and effective early warning system).

[34] PESETA, 2014. Climate IMpacts in Europe. The JRC PESETA II Project. Publications Office of the European Union in Luxembourg.

The cost of implementing measures, especially the early warning system, is significantly lower than the cost of inaction (even by several orders of magnitude). The benefits of implementation are very likely to exceed the costs of implementation, demonstrating, among other things, the high effectiveness of adaptation measures in this sector. Hunt et al. (2016)[35] evaluate the cost-effectiveness of heatwave early warning systems in selected European cities and conclude that these systems have a high benefit-to-cost ratio.

6.3.9 Tourism

Climate change is affecting the conditions for tourism, both natural and socio-economic. Socio-economic conditions are affected indirectly by climate change, through its impact on other economic areas and the overall economic stability of the region or country. This may mean a reduction in tourism potential due to the deterioration of basic facilities (accommodation), accompanying and transport infrastructure and the deterioration of complementary tourism services. The tourism most closely linked to climate change is 'sport and outdoor' tourism, which is closely linked to natural conditions. The winter sports season is the most affected by direct impacts on natural conditions. As the number of ice and frost days decreases, the amount of snowfall decreases and the period with snow cover shortens, the natural conditions for snow-related winter sports such as downhill skiing, cross-country skiing, ski mountaineering, snowboarding, etc. deteriorate. Furthermore, tourism, whose key potential is natural attractions whose existence may be threatened by climate change, is under threat.

Cultural heritage is a specific area where climate change may have negative impacts. The significance of the potential losses increases the irreplaceability of cultural heritage once lost. Climate change threatens cultural heritage, particularly through the effects of extreme events, but also through the long-term negative effects of climate conditions on objects and the potential acceleration of their degradation. Tourism itself also has an impact on greenhouse gas emissions through transport, accommodation and leisure activities. It is estimated that tourism accounts for 4.9% of global greenhouse gas emissions.

Climate change will have both negative and positive effects on tourism in the Czech Republic. On the one hand, rising average temperatures will extend the tourist season and thus (after appropriate investments in infrastructure) increase the income of the sector. On the other hand, it will shorten the winter tourist season and have a negative impact on winter tourism in mountain areas. The average snow cover is expected to decrease and the cost of artificial snow is expected to increase proportionally. It is likely that some traditional winter tourism areas will be impacted by a lack of natural snow and a decrease in the number of snow days, resulting in increased pressure on higher altitude resorts, which will also be at a relative advantage compared to lower altitude resorts. In the Czech Republic, the altitude with permanent snow cover is expected to shift from around 600 m above sea level at present to 630 m for the period 2021-2050 and up to 845 m for the period 2081-2100. Ski resorts in lower elevation mountain and foothill areas will be particularly at risk in the coming decades. The Adaptation Strategy of the Czech Republic points to the insufficient knowledge base for the definition of specific adaptation measures, but proposes a wide range of broadly defined adaptation measures that

[35] Hunt, A., Ferguson, J., Baccini, M., Watkiss, P., Kendrovski, V., 2016. Climate and Weather Service Provision: Economic Appraisal of Adaptation to Health Impacts. Climate Services. doi: 10.1016/j.cliser.2016.10.004.

can be implemented in the future for the sustainable development of tourism in the country. These include:

- Government measures (e.g. education and awareness programmes for stakeholders in the tourism sector),
- consumer measures (e.g. incentives to favour environmentally friendly tourism activities and destinations),
- research and communication (supporting research on the impacts of climate change on the tourism sector).

The implementation of these measures should be part of sustainable tourism strategies and the involvement of all stakeholders in tourism development is desirable. Promoting sustainable forms of tourism that take into account climate, environmental, economic and social aspects is important. Sustainable forms of tourism increase demand for 'local' destinations accessible by bicycle or public transport, active forms of travel, exploration of cultural and natural sites, etc. Other adaptation measures relate to research on the impacts of climate change on the tourism sector and its feedbacks on climate change. The tourism sector is vulnerable to the impacts of extreme hydrometeorological events. Adaptation measures related to these risks are described above, early warning systems can contribute significantly to the comfort of tourists and should also be considered in tourism strategies.

6.3.10 Emergencies

The broad spectrum of emergencies also includes the increased frequency and intensity of extreme weather events as possible manifestations of climate change, as described in the opening chapters of this study. Prevention of emergencies and mitigation of their impacts is dealt with at the strategic level in the Czech Republic, in particular in the Concept of Population Protection (MV 2013)[36]. On a practical level, the services resulting from the legislation on the Integrated Rescue System, Fire Protection, Crisis Management, etc. The Concept of Population Protection is complemented by the Concept of Environmental Safety 2016-2020 with a view to 2030, which focuses in particular on the prevention and mitigation of the consequences of disasters of both natural and technological origin in the environment.

According to the actual accepted definition, environmental safety is a state where the probability of occurrence of a crisis in the environment is still acceptable, and therefore various emergencies that can generally occur on the territory of the Czech Republic can be included in such crises. It is therefore currently accepted terminologically that a disaster is a crisis according to Act 240/2000 Sb. The Czech Republic, within the framework of its strategic concepts and the tasks arising from them, respects and implements the recommendations and requirements of the UN and the EU on disaster risk reduction, protection of the population, including activities leading to the maintenance of environmental safety; it supports adaptation to climate change and recognises the likely increased occurrence of crisis situations related to it, thus supporting the need to mitigate their impact. There is an emerging need to increase the resilience of people, cities and communities to disasters, including a greater need for two-way communication about disasters between professionals, government and citizens, preferably in

[36] MV, 2013. Koncepce ochrany obyvatelstva do roku 2020 s výhledem do roku 2030. Available online: www.vlada.cz/assets/ppov/brs/dokumenty/Koncepce-ochrany-obyvatelstva-2020-2030_1_.pdf.

the form of risk governance. The main expected impacts and risks of climate change on the population include:

- Increased frequency, intensity and variability of extreme weather events (especially prolonged droughts, extreme temperatures, heavy rainfall and their consequences,
- floods and flash floods,
- long-term climate change in the sense of a gradual increase in average annual temperatures of 2 °C or more, a gradual decrease with or change in the distribution of precipitation, with the consequent threat to ecosystem services,
- secondary impacts such as natural phenomena induced technological accidents (NATECH), subsequent manifestations of climate change impacts outside the Czech Republic such as migration waves or threats to raw material and food security.

Variants of emergencies in the conditions of the Czech Republic include a very wide range of events, all of which can be counted among the primary, secondary or tertiary manifestations and impacts of climate change or can be subsequently or synergistically triggered by them. Exceptional events generally include:

- Floods, including flash floods,
- special floods resulting from the breach of water works (dams, ponds, reservoirs, etc.),
- fires, large-scale wildfires and large-scale fires,
- extreme wind, snow and ice calamities,
- slope instabilities,
- epidemics,
- epizootics,
- shortage of water resources, prolonged drought,
- hailstorms,
- extremely high temperatures, heat waves,
- large-scale traffic accidents and disruptions (mass car crashes, major rail and air disasters),
- spills or leaks of hazardous pollutants (e.g. ammonia leaks from cooling equipment, chlorine leaks from water treatment plants, etc.) including NATECH,
- summer type smog situation (health threatening deterioration of air quality),
- restriction or interruption of electricity supply (blackouts),
- interruption of supply of essential commodities - food, drinking water, fuel, etc. and
- misuse of an environmental emergency for hostile acts (terrorism, armed conflict, etc.).

In the conditions of the Czech Republic, extreme weather events are the primary cause or at least an increasing factor of major hazards of natural origin. In addition, together with the nature of the landscape, often anthropogenically determined, they contribute to the emergence of phenomena such as long-term droughts (meteorological, agronomical and hydrological), floods and flash floods, extremely high temperatures, heat waves, landslides and natural fires, which then become secondary causes of a number of crisis situations. The likelihood of these situations is increasing due to climate change. In the Czech Republic, the Environmental Security Concept 2015-2020 with a view to 2030 has been issued, where the possible impacts of extreme weather events are defined and their determination.

A fluctuating to moderate increase in the number of emergencies can be expected by 2100. If the proposed adaptation measures are gradually implemented, it should be possible to keep the number of casualties and financial losses from these emergencies at the same level or even reduce them. The Czech Republic has a functioning crisis management system, including early warning systems, and its further development is expected in the coming period.

The aim of adaptation to climate change-related emergencies is primarily to protect the lives and health of the population, and then to protect critical infrastructure (e.g. power plants, pipelines, communication networks, transport), the environment and property. As the protection of critical infrastructure and assets is addressed in this chapter in a sectoral manner, the emphasis of this review is on the protection of life and health. Furthermore, no distinction is made between adaptations to different types of climate-related hazards, as there is considerable overlap (e.g. emergency plans).

The basic structure of the risk management framework has four successive phases in terms of the onset and progression of an incident:

- Prevention (avoidance of emergencies),
- preparedness (knowledge of the course of potential disasters and behaviour during them),
- response (application of contingency plans during the actual emergency),
- recovery (restoring the system to its pre-emergency/better state).

From the perspective of the protection of life and health of the population, two phases are essential - preparedness (the overall individual responsibility of each individual resident) and response (a predetermined procedure in the event of an emergency, according to crisis plans; deployment of the Integrated Rescue System). In terms of preparedness, in addition to the adoption of technical measures, an important step is the awareness of the population, awareness of potential threats and knowledge of basic patterns of behaviour in the event of an emergency. The preparedness of the population can be significantly increased through targeted information campaigns and the implementation or updating and possible extension of existing educational frameworks on emergency behaviour (especially primary school educational frameworks) and regular preventive exercises (e.g. evacuation drills). In addition to preparedness, which primarily focuses on the individual responsibility of each resident, a controlled, targeted and timely response is also important to eliminate the negative consequences of an ongoing emergency. Adaptation tools in this category include increasing the efficiency of crisis management at national and local level (investment in infrastructure and human resources), updating existing crisis plans to reflect the changes brought about by the changing climate (in accordance with the legislation in force, in particular Act 240/2000 Sb., the Crisis Act), and systematic development of the Integrated Rescue system units.

Given the expected increased frequency and intensity of climate change-related emergencies, it is necessary to increase investment in relevant adaptation measures accordingly. Since accurate prediction of the frequency and intensity of future emergencies and the behaviour of individual populations in specific crisis situations is problematic, it is neither possible to accurately estimate the number of lives that can be saved by implementing appropriate adaptation measures (especially soft measures such as information campaigns), nor to accurately determine the indirect gains of adaptation measures in the form of uninvested funds (e.g. funds saved for unspent health care). However, adaptation measures aimed at protecting the lives and health of the population in the event of expected emergencies can clearly be considered a priority and their implementation urgent.

6.4 Adaptation measures

The Czech Republic is already implementing a number of adaptation measures, especially in connection with water regime in the landscape and water management, forestry, agriculture and ecosystems.

The *Strategy on Adaptation to Climate Change in the Czech Republic* (hereinafter referred to as "Strategy") was first adopted by the Czech Government in October 2015 and is implemented by the *National Action Plan on Adaptation to Climate Change* (hereinafter referred to as "Action Plan") since January 2017. Preparation of both the Strategy and Action Plan was coordinatedby the Ministry of the Environment in cooperation with a number of Ministries and relevant scientific institutions. The Action Plan contains a list of adaptation measures and tasks, including responsibilities for implementation, deadlines, identification of relevant funding sources and an estimate of the costs of implementing the measures.

The first update of both the Strategy and Action Plan was approved by the Government of the Czech Republic on 13 September 2021. More than 170 experts from public, scientific and non-profit institutions participated in the update of both documents. The materials are based mainly on expert documents prepared by the Ministry of the Environment (CHMI and CENIA) with the support of the Czech Academy of Sciences (especially CZECHGLOBE - Institute of Global Change Research of the Czech Academy of Sciences) and a number of other research organisations.

The following documents were the key analytical basis for updating the adaptation strategy and action plan:

- Update of the 2015 Comprehensive Study of Impacts, Vulnerability and Sources of Climate Change-related Risks in the Czech Republic (team led by the CHMI, 2019);
- Evaluation of the implementation of the National Action Plan for Adaptation to Climate Change (CENIA and MoE, 2019);
- Vulnerability assessment of the Czech Republic in relation to climate change as of 2017 (CENIA, 2019).

The Strategy, which is based on the relevant EU documentation, has been adjusted to specific conditions of the Czech Republic. The Strategy presents observed climate change and defines the adaptation measures including their mutual linkages in connection to anticipatedimpacts of these changes.

Adaptation measures are proposed in the following sectors (fields of impact of climate change):

- Forest management
- Agriculture
- Water regime in landscape and water management
- Biodiversity and ecosystem services
- Health and hygiene
- Urban landscape
- Tourism and recreation

- Industry and energy sector
- Transportation
- Cultural heritage
- Safe environment.

Climate change manifestations in the Czech Republic:

- Long- term droughts,
- Floods and flash floods,
- Heavy rainfall,
- Rising temperatures,
- Extremely high temperatures,
- Extreme wind, and
- Wild fires.

Both the Strategy and Action Plan focuses on all major climate change manifestations in the Czech Republic. The Action Plan elaborates further the measures outlined in the Strategy into specific tasks, which assign responsibilities, implementation deadlines, relevance of measures to individual climate change impacts and sources of financing.

Adaptation measures should be, where possible, conducted in accordance with measures to reduce emissions and increase their sinks (mitigation measures). Positive synergy and interaction in the field of adaptation and mitigation is possible and desired (e.g. in landscape management). On the other hand, inappropriate adaptation measures are those that do not increase the resilience of ecosystems or increase their vulnerability, are environmentally unbalanced, financially inefficient or contradict the objectives of other policies.

The most important principles of adaptation to climate change in the Czech Republic are:

- an integrated approach both in assessing the synergy of adaptation and mitigation measures as well as in assessing the suitability of the proposed measures for individual environmental, economic and social spheres;
- the priority implementation of solutions with multiple effects on the side of benefits (win-win solutions) and low negatives on the side of risks or costs (low-regret options);
- the identification of opportunities associated with the adaptation process;
- the prevention of inappropriate adaptation; and
- the building of a knowledge base and the provision of objective information for decision-making processes at all levels.

Regardless of the temperature rise scenarios as well as how successful the mitigation efforts prove to be, the impacts of climate change will increase in the coming decades due to the delayed impact of the increase in greenhouse gas emissions. Adaptation measures must therefore be taken to address the unavoidable impacts of climate change and their economic, environmental and social costs.

Climate change increases society's vulnerability to a wide range of impacts on socio-economic and natural systems, so it is necessary to address these unavoidable consequences both by reducing vulnerability and increasing resilience (EEA, 2010a).

From the point of adapting to climate change, ecosystem services provided by natural or close-to-natural ecosystems are key, including in-field strips and patches, field wetlands, etc. The provision of ecosystem services by these habitats does not necessarily entail the need for new financial costs – in some cases it is sufficient to maintain them, and it is desirable to develop them in order to increase the adaptation capacity of the area.

All adaptation measures must be implemented in accordance with the applicable legislation, must undergo a standard approval process and take into account the subjects of protection of special protection areas and the conservation objectives of these areas. In order to ensure the obligations arising from EU legislation, respect for the conservation objectives of Natura 2000 sites will be taken into account in the implementation of the measures. When the Natura 2000 sites are affected, priority will be given to solutions of specific projects implemented within individual measures that do not have a negative impact on the objects of conservation and at the same time, if the nature of the measures allows it, they will encourage the occurrence of the subjects of protection in the given sites (e.g. the restoration of small water reservoirs or the revitalisation of water courses in a way that complies with the requirements of the object of conservation linked to the given habitat type; the choice of appropriate localisation of measures with regard to the occurrence of the objects of conservation in the territory, etc.). During the preparation of measures of a conceptual nature, solutions eliminating the effects on the objects of protection of Natura 2000 sites will be chosen. When implementing projects or preparing concepts related to this material that could, individually or in conjunction with others, have a significant impact on the favourable condition of the object of conservation or the integrity of a European significant site or bird area, the objective of preventing or eliminating the impacts on Natura 2000 sites will be pursued and the procedure under Act No.114/1992 Coll., on Nature and Landscape Protection will be applied.

6.4.1 Vision of adaptation to climate change in the Czech Republic

The Czech Republic in 2050:

- has a high-**quality and safe environment** in which the risks of the impacts of climate change and related threats of natural origin are reduced and maintained at an acceptable level and an effective response to the occurrence of emergencies caused by climate change is ensured;
- maintains a restored **complex and functional landscape structure including human settlements**, which has increased its ecological stability and the extent and quality of the ecosystem services provided;
- **uses the landscape and ecosystems in a sustainable manner** that allows sufficient flexibility to respond to ongoing climate change and to mitigate its adverse impacts on the economy and ecosystems; the **costs and benefits** associated with the implementation of adaptation measures are **fairly shared by the whole society**;
- **is a state where public administrations, entrepreneurs and other actors, including professionals and the general public**, are adequately informed about climate change and its impacts, actors at all levels take their responsibility to strengthen the adaptation capacity of the social, economic and environmental system and increase its resilience in a cost-effective manner.
- **sustainably manage and care for water resources and land**, in particular for the needs of providing drinking water to the population and preventing soil erosion.

6.4.2 Strategic objective

To increase the Czech Republic's preparedness for climate change – to reduce vulnerability and increase the resilience of human society and ecosystems to climate change and thus reduce its negative impacts.

6.4.3 Specific objectives

Specific objectives have been formulated to capture the basic landscape types in the Czech Republic while allowing to respond to the **major climate change manifestations in the Czech Republic**.

	Specific objective	Relevant climate change manifestations
SO1	**Ecological stability and the provision of ecosystem services in agricultural landscapes are ensured, with emphasis on reducing both soil degradation and land take and strengthening the natural water regime.**	• Long-term drought; • Floods and torrential floods; • Heavy rainfall; • Increasing temperatures; • Extremely high temperatures; • Extreme winds; • Vegetation fires
SO2	**Ecological stability and the provision of ecosystem services of forests are ensured, with emphasis on preventing soil degradation and strengthening the natural water regime.**	• Long-term drought; • Floods and torrential floods; • Heavy rainfall; • Increasing temperatures; • Extremely high temperatures; • Extreme winds; • Vegetation fires
SO3	**Ecological stability and the provision of ecosystem services of aquatic and water-bound ecosystems are ensured, with emphasis on strengthening the natural water regime of the landscape and with regard to safeguarding the needs of human society and sustainable use of water.**	• Long-term drought; • Floods and torrential floods; • Increasing temperatures; • Extremely high temperatures;
SO4	**The resilience of human settlements, including their public and green infrastructure, is significantly enhanced, with emphasis on the protection of human health.**	• Long-term drought; • Floods and torrential floods; • Heavy rainfall; • Increasing temperatures; • Extremely high temperatures; • Extreme winds;
SO5	**The high efficiency of the early warning system and the responsible response of the population is achieved.**	• Long-term drought; • Floods and torrential floods; • Heavy rainfall; • Extremely high temperatures;

		• Extreme winds; • Vegetation fires

6.4.4 Framework of adaptation measures to climate change for the years 2021-2025

SO1 Environmental stability and provision of ecosystem services in agricultural landscapes is ensured, with emphasis on reducing both soil degradation and land take and strengthening the natural water regime

1.1 Legislative, financial and material support for land consolidation with respect to climate change

1.2 Organisational support for land consolidation

1.3 Complex land consolidation with respect to increasing the retention capacity and ecological stability of the landscape

1.4 Research in mitigation and prevention of the potential impacts of climate change on the agricultural sector

1.5 Measures to reduce the water and wind erosion of agricultural land

1.6 Maintaining and increasing the water-holding capacity of the soil

1.7 Stable support and promotion of organic farming, with emphasis on non-production and adaptation functions

1.8 Construction of new and modernisation of existing irrigation systems

1.9 Minimising the impact of inappropriate drainage facilities on accelerated water runoff from the landscape

1.10 Application of technologies and methods to reduce the unproductive evaporation and promote more efficient use of soil moisture by crops

1.11 Support of farming systems and landscape design concept contributing to increasing resilience to climate change

1.12 Promoting adaptation to climate change within the framework of the Common Agricultural Policy Strategic Plan

1.13 Ensuring the economic sustainability of agricultural management in the landscape together with its production function

1.14 Diversification of agricultural activities

1.15 Increasing the availability of an early warning system for extreme weather events for farmers

1.16 Supporting the risk management system to combat pests and diseases threatening agricultural crops

SO2 Environmental stability and provision of ecosystem services of forests is ensured with emphasis on preventing soil degradation and strengthening the natural water regime

2.1 Achieving game populations that will enable natural regeneration of a wide range of tree species.

2.2 Support of forest management practices with permanent land cover and long or continuous restoration periods

2.3 Preferring and ensuring natural forest restoration

2.4 Increasing ecological stability of forest stands and their resistance to both biotic and abiotic pests by selecting the appropriate species and spatial composition

2.5 Identifying risk areas for priority implementation of adaptation measures in forest ecosystems

2.6 Developing best management practices (BMP) for forest owners and professional forest managers

2.7 Protection of the gene pool of domestic, climate-endangered forest tree populations

2.8 Ensuring sufficient biomass as an energy source with regard to the need to maintain sufficient amounts of organic matter in the soil

2.9 Promoting a risk management system of biotic pests of forest and ornamental tree species

2.10 Establishing the preconditions for efficient and sustainable use of forest tree genetic resources

2.11 Ensuring the registration of genetic resources of forest tree species

2.12 Revising the measures of forest engineering ameliorations, torrent control, and forest roads with a focus on the protection and restoration of the natural water regime in forests

2.13 Minimising technical drainage of forest land by using natural processes and nature-friendly practices

2.14 Implementation of water retention measures in forests

2.15 Application of harvesting and reforestation procedures and measures to prevent or slow down the accelerated surface runoff of rainwater and to prevent soil erosion

2.16 Stabilization the area of forest type groups which are affected by water and protection of wetlands in forests

SO3 Environmental stability and provision of ecosystem services of aquatic and water-bound ecosystems is ensured with an emphasis on strengthening the natural water regime of the landscape and with regard to safeguarding the needs of human society and sustainable use of water

3.1 Legislative regulation of the conditions for the operation of combined sewer overflows and requirements for the capture and subsequent treatment of these waters

3.2 Comprehensive revitalization of watercourses and floodplains and support of spontaneous ecosystem renaturation

3.3 Preventive protection of water resources – protected zones of water resources, protected areas of natural water accumulation and areas protected for accumulation of surface water

3.4 Revision of water protection areas and activities that could negatively affect the quality and quantity of water

3.5 Restoration of water management function of small water reservoirs not fulfilling the necessary functions in the territory

3.6 Promotion of surface water infiltration into groundwater

3.7 Re-evaluation of existing use of water reservoirs and water management systems and optimisation of their management

3.8 Examining the need to implement new water resources in areas with proven water scarcity

3.9 Rational decision-making in permitting water withdrawal and discharges

3.10 Introducing and promoting water reuse and water recycling systems for non-potable water

3.11 Examination of the need for hydric use of mine works and quarries for water accumulation or retention

3.12 Restoration of floodplains to natural and managed flooding

SO4 The resilience of human settlements, including their public and green infrastructure, is significantly enhanced with emphasis on the protection of human health

4.1 Establishing a decentralised rainwater management system

4.2 Developing a comprehensive concept for the management of drought and water scarcity and for the prevention of emergency events caused by long-term water scarcity

4.3 Introducing risk analysis and management methods in the drinking water production and distribution process

4.4 Taking into account adaptation measures in the plans for development of water supply and sewerage

4.5 Supplying water scarcity areas by transferring water from another water supply system to overcome long-term droughts

4.6 Minimising the salting of roads and the use of herbicides and pesticides in settlements

4.7 Taking flood risk into account in the design and planning of buildings and other projects in vulnerable areas

4.8 Preventive relocation of strategic assets and potentially hazardous substances out of reach of possible flooding

4.9 Prioritising the use of flood protection measures with minimal negative impacts on the ecological status of waters, nature and landscapes

4.10 Ensuring safe transfer of increased water flows through built-up parts of municipalities using technical measures in combination with nature-friendly measures

4.11 Paying increased attention to protection against flash floods in the preparation of flood risk management plans

4.12 Planning in the area of risk prevention and management of an urban heat island

4.13 Regulating the densification of settlements at the expense of free areas and green areas in the determination of built-up areas

4.14 Planning and development of systems of urban greenery and water areas within urban development in relation to density and population for increasing functional quality

4.15 Establishing, developing and caring for systems of urban greenery and water systems with a view to increasing the proportion, quality and functional efficiency of urban greenery and water areas, including their interconnection

4.16 Adaptation of building standards, norms and certifications related to building structures for new constructions and reconstructions to the impacts of climate change

4.17 Ensuring a coordinated approach for vulnerability assessment of buildings

4.18 Implementation of programmes aimed at the public sector contributing to the adaptation of public buildings to climate change

4.19 Promoting programmes aimed at the residential and commercial sectors contributing to the adaptation of buildings to climate change

4.20 Building solutions leading to a reduction of the heat stress of the population

4.21 Promotion of technologies using renewable energy sources for cooling and air-conditioning of buildings

4.22 Introducing responsible management tools to support adaptation to climate change by reducing the ecological footprint of settlements resulting from increasing demands on built-up areas, transport, food, water, heating, services

4.23 Ensuring the diagnosis and treatment of diseases spreading in the Czech Republic in relation to climate change and strengthening prevention

4.24 Integrating tourism into the formulation and implementation of strategies and resulting plans

4.25 Setting up incentive measures for tourism

4.26 Promoting and supporting interdisciplinary cooperation in the field of tourism at all levels of management, networking and information exchange, and development of destination management

4.27 Addressing the protection of heritage sites from the negative impacts of climate change

4.28 Stimulating interdisciplinary research on the impacts of climate change on tourism and the impact of tourism on climate change

4.29 Adopting recommendations or regulations on systematic planting and selection of tree species at a suitable distance along roads and railways

4.30 Taking into account the manifestations of climate change in the context of updates of transport sector strategies

4.31 Using telematic transport systems

4.32 Air conditioning and heating of public transport vehicles with regard to high efficiency and economy

4.33 Increasing the efficiency of the use of water resources in production processes

4.34 Adapting current safety measures (crisis and emergency plans) and risk management systems in industrial facilities

4.35 Ensuring energy security in the context of climate change

4.36 Ensuring the availability of biomass as an energy source and promoting energy sources whose production is environmentally friendly and economically viable

4.37 Stabilising sites of slope instability in emergency condition through stabilising elements

4.38 Developing methods to reduce the vulnerability of society and increase resilience to meteorological extremes

4.39 Supporting research, development and innovation in the field of environmental security

SO5 High efficiency of the early warning system and responsible reaction of the population is achieved

5.1 Ensuring basic organisational and technical measures (prediction, warning, evacuation, rescue, coordination, etc.)

5.2 Ensuring awareness increasing the preparedness of the population to cope with crisis situations

5.3 Developing early warning systems for the population against flash floods

5.4 Developing a warning system for periods of extremely high temperatures

5.5 Strengthening and developing an integrated rescue system (IRS)

5.6 Ensuring the infrastructure of the Fire Rescue Service of the Czech Republic and municipal volunteer fire brigades

5.7 Developing the technical support for emergency calls, the transfer of information between IRS units, and the PEGAS radio communication system

5.8 Improvement of forecasting, warning and reporting services and monitoring systems and their harmonisation with EU/global systems

5.9 Analysis and proposal of corresponding legislation modification in the field of prevention of vegetation fires

5.10 Monitoring and analysis of the status and regime of the atmosphere, hydrosphere and lithosphere (in particular of risk slopes) and development of the basis for preventive measures

CCA Cross-cutting actions

CCA.1 Establishment of a system for valuation and assessment of essential ecosystem services and its integration into policy and legislation at national and regional level

CCA.2 Establishment of green budgeting, i.e. systematic monitoring of the state budget expenditure and expenditure from the European funds according to purpose in relation to adaptation to the impacts of climate change

CCA.3 Rationalisation of subsidy management, taking into account potential benefits and costs to mitigate climate change impacts and elimination of environmentally harmful subsidies

CCA.4 Protection and support of planning, establishment, restoration, and maintenance of green infrastructure providing diverse ecosystem services and mitigating the negative effects of climate change

CCA.5 Implementation of measures against the spread of invasive alien species of plants and animals and their regulation or eventual eradication, ensuring active active management and synergies

CCA.6 Compensation of damages from public funds is conditional on implementation of adaptation measures

CCA.7 Taxes, fees and other similar monetary payments are reflecting the negative externalities of economic activity on society and eliminated environmentally harmful tax advantages

CCA.8 Functional risk sharing – in particular on a market basis with adequate state support

CCA.9 Ongoing education, training and awareness raising in the field of climate change and adaptation

CCA.10 Ongoing methodological, educational and financial support for developing adaptation strategies and implementing adaptation measures

CCA.11 Ensuring and sufficient support for research, development and innovation in the field of climate change and adaptation

CCA.12 Existing knowledge base for mitigation of climate change impacts is continuously updated and put into practice

CCA.13 Active and constructive involvement of the Czech Republic in international and EU processes in the field of climate change adaptation

CCA.14 Formulating national priorities for landscape planning as a basis for coordination of procedures and activities of individual ministries in landscape use

CCA.15 Transition to planning and sizing of water management measures in the landscape taking into account projected climate change

7 PROVISION OF FINANCIAL, TECHNOLOGICAL AND CAPACITY-BUILDING SUPPORT TO DEVELOPING COUNTRY PARTIES

The Czech Republic is not a party to Annex II to the Convention and as such is not obliged to adopt measures, in line with Article 12.3 of the Convention and fulfil obligations pursuant to Articles 4.3, 4.4 and 4.5 of the Convention and provide additional financial sources. Nevertheless, the Czech Republic as the EU member state, along with other developed countries committed itself at the 15th session of the Conference of Parties to the Convention in December 2009 in Copenhagen, to a goal of mobilizing jointly USD 100 billion annually by 2020 to address the needs of developing countries in the context of meaningful mitigation and adaptation actions and transparency on its implementation. Therefore, the Czech Republic is pleased to provide on a voluntary basis available information on the support provided to developing countries for activities related to climate change.

The Czech Republic has been providing climate specific support to developing countries since 2010. The Development Cooperation of the Czech Republic (DC) is the main means through which the climate financing and the technology transfer support have been delivered to developing countries. For the reporting purposes the climate specific funding has been identified in accordance with the OECD-DAC methodology. Only projects with adaptation or mitigation RIO Markers (significant or principal objective) are accounted towards the climate specific funding. The DC has two main delivery channels a) The Bilateral Development Cooperation (BDC) and b) The Multilateral Development Cooperation (MDC). Key strategic document is the Development Cooperation Strategy of the Czech Republic 2018–2030, which define territorial and sectoral priorities of foreign development cooperation of the Czech Republic and reflect international commitments and actual challenges in development cooperation area.

The main framework for development and humanitarian activities between 2015 and 2030 is defined by Agenda 2030 adopted in September 2015. Agenda 2030 defines seventeen Sustainable Development Goals (SDGs) and sets the objectives for global development until 2030, interlinking the economic, social and environmental dimensions of development. The Czech Republic's development activities focus on five thematic priorities: from building stable and democratic institutions, through sustainable management of natural resources, agriculture and rural development to inclusive social development and economic growth. In the implementation of development and humanitarian activities, the Czech Republic uses both project and financial instruments to efficiently achieve the intended results, including the interconnection of its bilateral cooperation with the financial instruments of the EU, the UN and other international organizations and financial institutions.

7.1 Bilateral Development Cooperation

The Ministry of Foreign Affairs is the main administrator of activities related to BDC. However, the coordination and coherence of the BDC are also the responsibility of the inter-ministerial Council on Development Cooperation, where all Ministries take part and contribute to the formulation of Czech policies in their specific areas of expertise. The implementation body of the BDC is the Czech Development Agency, established in January 2008, which is responsible for the provision of development cooperation including the identification of suitable projects, their wording, the advertising of competitions (in the form of public contracts and grants), the signing of contracts and monitoring of projects. In the choice of partner countries, the Czech Republic focus and will focus, according to the Development Cooperation Strategy of the Czech Republic 2018–2030, in balanced way on cooperation with low-income countries (LDCs, Least Developed Countries) as well as with middle-income countries (MICs) in terms of OECD classification. A new list of priority partner countries of the Czech Republic was approved for the period from 2018 onwards (Government Resolution No. 631 of 11 July 2016). It includes Bosnia and Herzegovina, Cambodia, Ethiopia, Georgia, Moldova, and Zambia. In addition, the cited Government Resolution establishes the category of Specific Countries, currently including Afghanistan, Palestine, Ukraine, and Syria. The list of specific countries may be amended and supplemented by government resolutions to reflect, inter alia, the Government's interest to developing partnerships or targeted support of selected countries in the context of a post-conflict stabilization and reconstruction processes.

In 2020, the implementation of development cooperation projects was significantly affected by the COVID-19 pandemic. Thanks to the timely response of the Czech Ministry of Foreign Affairs and the government, special assistance was provided in priority countries of the Czech development cooperation and in the region of Africa. Restrictions related to the spread of COVID-19 hindered the implementation of planned activities throughout the year. However, when possible, the projects were either adjusted (mainly transferred to the online environment), or rescheduled to the following year.

Thanks to activities of the Czech Development Agency, 462.3 mill. CZK was disbursed in 2020 in the following countries.

Table 7.1 Official development aid provided by the Czech Development Agency to priority partner countries in 2020

Country	Disbursement in 2020 (mill. CZK)
Moldova	85.3
Ethipia	76.7
Bosnia and Herzegovina	66.2
Zambia	52.5
Georgia	43.1
Cambodia	17.6

Source: MFA[37]

As for the activities of the Ministry of Foreign Affairs, 60 small scale projects were implemented in 39 developing countries (23.96 mill. CZK) to support the activities of local subjects, 7.94 mill. CZK was disbursed to strengthen capacities of public higher education institutions in partner countries, 40 mill. CZK was donated to Afghanistan for development and security programmes, 50 mill. CZK was donated to support the International Development

[37] https://www.mzv.cz/public/8f/be/ea/4343748_2665000_ENG_Information_ODA_summary.pdf

Cooperation Guarantee programme, 86.67 mill. CZK was disbursed to projects supporting human rights and democracy (Transformation Cooperation Programme) and other various projects were implemented in cooperation with other line ministers.

Detailed overview of climate specific bilateral projects supported by the Czech Republic is included in CTF table 7b) of the Biennial Reports of the Czech Republic.

7.2 Multilateral Development Cooperation

The Czech Republic is also involved in a number of multilateral activities overseen by a number of international organizations, which aim to achieve global development objectives and other international commitments. The Czech Republic participates in and contributes to funding of development activities of the UN, EU, OECD, international financial institutions and other organizations. For the purposes of the Strategy the Czech Republic considers only those organizations whose activities are in line with OECD-DAC definition of development cooperation and contributions provided are fully or partially creditable towards official development assistance (ODA). Organizations were divided into four groups: 1) EU, 2) development banks and financial institutions, 3) programs and funds of the UN, and 4) other organizations. The Czech Republic is a member of the Development Assistance Committee OECD (DAC) since 14 May 2013.

In 2020, The Czech financial contribution to the development agenda of the European Union accounted for 2/3 of the total official development assistance provided by the Czech Republic. Czech Republic was involved in the common response of the EU and member states to the pandemic in partner countries under the Team Europe initiative. Also, preparations commenced for the Czechpresidency in the Council of the EU in 2022. The Czech Republic has also continued the cooperation with the United Nations (UN), especially with the UN's Development Programme (UNDP). The long-term project "Czech-UNDP Partnership for Sustainable Development Goals" successfully progressed. In January 2020, the Czech Republic began its three-year long membership in the UNDP Executive Board. Within the UN, the Czech Republic has also been involved in other programmes, e.g. the UN volunteers programme (UNV).

Detailed overview of our multilateral funding is included in CTF table 7a) of the 5th Biennial report of the Czech Republic. In 2019, the climate specific funding of MDC has been channelled to the two main international funds i.e. the Global Environmental Fund and the Multilateral Fund for the Implementation of the Montreal Protocol. Furthermore, the Czech Republic also contributed to the International Bank for Reconstruction and Development, the International Development Association and the United Nations Development Programme. In 2020, the climate specific funding of MDC has been channelled to the Global Environmental Fund, the International Development Association, the International Bank for Reconstruction and Development, the Council of Europe Development Bank and the United Nations Framework Convention on Climate Change (UNFCCC).

In October 2022 the Czech Government has decided to annualy contribute 1 mill. USD to the Green Climate Fund in the years 2024 to 2027.

Table 7.2 The overall 2017–2020 climate specific funding from Bilateral and Multilateral Development Cooperation of the Czech Republic (in EUR)

Allocation channels	2017			2018		
	Mitigation	Adaptation	Cross-cutting	Mitigation	Adaptation	Cross-cutting
Total contributions through multilateral channels			1 838 567			1 008 586
Total contributions through bilateral, regional and other channels	1 368 176	3 360 020	498 389	1 404 732	4 062 331	725 722
Total climate specific by funding type (total for mitigation, adaptation, crosscutting, other)	1 368 176	3 360 020	2 336 956	1 404 732	4 062 331	1 734 307
Total climate specific finance	**7 065 152**			**7 201 370**		

Allocation channels	2019			2020		
	Mitigation	Adaptation	Mitigation	Adaptation	Mitigation	Adaptation
Total contributions through multilateral channels						
Total contributions through bilateral, regional and other channels	1 943 062	3 538 680	1 943 062	3 538 680	1 943 062	3 538 680
Total climate specific by funding type (total for mitigation, adaptation, crosscutting, other)	1 943 062	3 538 680	1 943 062	3 538 680	1 943 062	3 538 680
Total climate specific finance	**7 471 745**			**11 725 343**		

7.3 Technology transfer and capacity building

The core objective of the Czech Republic´s development cooperation and humanitarian assistance is to contribute - using its capacities and experience and in line with international commitments - to building a stable, secure, inclusive, prosperous and sustainable world and to strengthen its position within it. Very important parts of the development cooperation and also of the Sustainable Development Goals embody the technology transfer and capacity building.

Regarding the technology development and transfer and capacity building projects, the Czech Republic has implemented several bilateral projects within its ODA that contributed to the technology development and transfer to developing countries and capacity building in these countries. More information is provided in CTF tables 7b) and 9 of the 5th Biennial Report of the Czech Republic.

7.4 Information according to Article 10 of the Kyoto Protocol

Information provided according to Article 10 of the Kyoto Protocol to be provided within the framework of the 8^{th} National Communication is provided in Annex 2.

8 RESEARCH AND SYSTEMATIC OBSERVATION

This chapter summarizes information on the structure of research in the area of climate change and its main results in the period since the Seventh National Communication of the Czech Republic to UNFCCC. It also provides basic information on the ongoing systematic observation and archiving of climatological data.

This research is intended particularly to improve knowledge of the causes, effects, magnitudes and temporal factors of climate change and their sectoral, economic or social consequences. Attention is also devoted to international cooperation and exchange of scientific, technical and also socio-economic information.

8.1 General organization of research and systematic observation

Research on aspects connected with the current state and development of the climate system is concentrated particularly in the following institutions:

- Institutes of the Academy of Sciences of the Czech Republic (Global Change Research Institute AS CR, public research institution – CzechGlobe; Institute of Atmospheric Physics AS CR, public research institution; Geophysical Institute AS CR, public research institution; The Institute of Hydrodynamics of the AS CR, public research institution; Institute of Systems Biology and Ecology, public research institution; Institute of Geology AS CR, public research institution)
- University departments (Faculty of Mathematics and Physics, Charles University in Prague; Faculty of Science, Masaryk University; Faculty of Science, Charles University in Prague; University of South Bohemia in České Budějovice; the Mendel University in Brno)
- Sectoral institutes (Czech Hydrometeorological Institute; National Institute of Public Health; the T.G. Masaryk Water Research Institute, public research institution; Czech Geological Survey) and other research institutes (Crop Research Institute, public research institution; Research Institute of Agricultural Engineering, public research institution; Research Institute of Ameliorations and Soil Conservation public research institution; etc.).

The research, which is part of the basic tasks of the individual institutions, is financed both from their budgets and also through the grant schemes. The most important grant providers are the Grant Agency of the CR, the Technology Agency of the CR (esp. the programme Environment for Life conducted by the Ministry of the Environment) and the Ministry of Agriculture. Some projects are carried out in the framework of international cooperation and co-financed by foreign partners – both on the EU level (programmes Horizon 2020 and Horizon Europe) and on the bilateral basis (e.g. with neighbouring countries, Norway and Israel). Under the Horizon Europe programme, the Ministry of the Environment, in cooperation with TA CZ, is involved in several European Partnerships related to the climate change (Biodiversa+, Water4All, Clean Energy Transition Partnership).

Systematic observation of the climate system is carried out mostly by the Czech Hydrometeorological Institute (CHMI) which performs the function of the State institute for the area of air quality protection, hydrology, water quality, climatology and meteorology, with a competence to establish and operate State monitoring and observation networks, including international data exchange pursuant to the WMO principles. Czech Hydrometeorological Institute is responsible for National Greenhouse gas inventory and database. Other institutions carry out monitoring for their own needs, usually for a limited period of a certain project.

Exchange of scientific and technical information between Czech and foreign institutions is not regulated in any way and occurs quite freely; CHMI provides climate and hydrological data free of charge, fee might be applied for additional service in support of data provision like data conversion, surveillance, or hosting.

The Global Change Research Institute of the Czech Academy of Sciences (CzechGlobe) provides trainings to Ph.D. students and experts (researchers, technicians, public service) from various developing countries. Thanks to established long-term collaboration (agreements, joint projects, research mobilities, visiting professorships…) with national partners (universities, research centres, governments, NGOs…) are prepared joint projects leading to creation of research sites of greenhouse gases cycles research in tropical ecosystems + related global change research in Vietnam and Ghana.

Based on the project of the EU programme Horizon 2020 of SEACRIFOG (2017–2019) has been provided by CzechGlobe trainings and knowledge transfer in climate change adaptations and climate services related to food security to African experts from public service and academia (mainly from Ghana, Sudan, Kenya, Cape Verde, Ethiopia, South Africa, Namibia). CzechGlobe has been conducting related research across Europe (e.g. Germany, Austria, Latvia, Romania, Georgia) and beyond (e.g. Ghana, South Africa, Peru, Kyrgyzstan) and also coordinated UN project and tender collaborations such are Programme for facilitating the engagement with and access to the Green Climate Fund for Serbia and/or other countries of the Western Balkans (2018-2019) or Elaboration of Legal and Institutional Framework for Multi-hazard Early Warning System and Climate Information in Georgia. CzechGlobe has also been engaged in numerous high-profile research projects within extensive international networks. Members of the department are actively engaged in science-policy interfaces (e.g. UN IPBES, EKLIPSE, ICGdR).

The CzechGlobe provides also regular visiting lectures and trainings at universities in Bolivia and Columbia dedicated to biodiversity research and protection in the context of climate and global change.

Major ongoing long-term research (2020-2026) project funded by the Environment for Life program under Technology Agency of the Czech Republic dealing with Climate change impact modelling an assessment is PERUN (**P**rediction, **E**valuation and **R**esearch for **U**nderstanding **N**ational sensitivity and impacts of drought and climate change for Czechia) coordinated by the Czech Hydrometeorological Institute.

In addition to participation in the activities of the WMO and UN Environmental Programme (UNEP), the Czech Republic cooperates on a number of international projects concerned with the climate. The most important in this respect is participation in the RC LACE project (the ARPEGE-CLIMAT model). Recently, participation of the Czech Republic in international projects concerned with modelling the climate system and estimation of the impacts of climate change has expanded substantially. The Czech Republic for example participates in the Intergovernmental panel on Climate Change (IPCC), the World Climate Programme (WCP WMO), the International Geosphere-Biosphere Programme (IGBP) and the Global Climate

Observing System (GCOS WMO). The cooperation is mainly based on data delivery to relevant databases and international exchanges.

The Czech Republic regularly provides assistance to developing countries in various ways: direct financial support, technology development and transfer (mostly on bilateral) and capacity building (e.g. training courses and assistance in installation and calibration of instruments).

8.2 Research projects, experimental development and innovations 2018–2021

For the period covered by this 8th National Communication, 112 research, development and innovations projects related to climate change were identified by qualified selection. This includes projects initiated and completed within this period, projects commenced prior and completed within this period and projects initiated in this period and continuing beyond this period. Some of these projects were commenced during the 7th National Communication. The Research and Development and Innovations Information System of the Czech Republic (R&D IS) is the source of information on these projects.

The total volume of funding provided to R&D projects reached 1325.6 million CZK. The funding structure in individual years is given in the table below.

Table 8.1: Actual funding provided toward R&D (climate change) projects from the state budget in 2018–2021

Year	**million CZK**
2018	373.3
2019	317.1
2020	280.5
2021	354.7
Total	**1325.6**

Source: R&D IS

Table 8.2: Actual funding provided toward R&D (climate change) projects from the state budget in 2018– 2021 according to provider (millions of CZK)

Provider / Source	**2018**	**2019**	**2020**	**2021**	**TOTAL**
Ministry of Education, Youth and Sports (MEYS)	283.4	224.2	171.3	166.2	**841.2**
Technology Agency (TA CZ)	12.6	19.3	44.2	111.9	**188.0**
Czech Science Foundation (GA CZ)	38,0	35.9	35.7	48.4	**158.0**
Ministry of Agriculture (MoA)	8.5	15.4	12.3	22.6	**58.8**
The City of Prague	25.9	17.6	8.9		**52.4**
Ministry of the Interior of the Czech Republic	5.0	4.8	8.0	9.6	**27.3**
Total	**373.3**	**317.1**	**280.5**	**354.7**	**1325.6**

Source: www.rvvi.cz

Chief beneficiaries

R&D projects focused on climate change were implemented between 2018 and 2021 mainly by the following organizations (number of projects given in brackets):

Charles University (17), Global Change Research Institute of the CAS, public research institution, public research institution (16), Czech University of Life Sciences in Prague (CZU) (12), Institute of Botany of the CAS, public research institution (12), Biology Centre of the CAS, public research institution (8), Masaryk University (7), Institute of Vertebrate Biology of the CAS, public research institution (4), Mendel University in Brno (4), The T. G. Masaryk Water Research Institute, public research institution (4), Czech Geological Survey (3), Czech Hydrometeorological Institute (3), Institute of Atmospheric Physics of the CAS, public research institution (3), Institute of Microbiology of the CAS, public research institution (3), Forestry and Game Management Research Institute, public research institution (3), Research Institute of Ameliorations and Soil Conservation, public research institution (2), University of Ostrava (2), University of South Bohemia in České Budějovice (2), Institute of Chemical Process Fundamentals of the CAS, public research institution (1), Institute of Sociology of the CAS, public research institution (1), J.E.Purkyně University (1), RD Rýmařov s. r. o. (1), Research Institute Of Brewing and Malting (1), The Silva Tarouca Research Institute for Landscape and Ornamental Gardening, public research institution (1), University of West Bohemia (1).

8.3 Information on selected important national research projects

A number of important national research projects focusing on climate change have been supported since 2018; these include:

- Prediction, Evaluation and Research for Understanding National sensitivity and impacts of drought and climate change for Czechia (provider TA CZ, chief beneficiary Czech Hydrometeorological Institute)
- Water systems and water management in the Czech Republic in conditions of climate change (provider TA CZ, chief beneficiary The T. G. Masaryk Water Research Institute)
- SustES - Adaptation strategies for sustainable ecosystem services and food security under adverse environmental conditions (provider MEYS, beneficiary Global Change Research Institute of the Czech Academy of Sciences)
- CzechGlobe 2020 – Development of the Centre of Global Climate Change Impacts Studies (provider MEYS, beneficiary Global Change Research Institute of the Czech Academy of Sciences)
- Drough Stories: Local Contexts of Extreme Climate Events, their Perception and Willingness of Actors to Public Participation (provider TA CZ, beneficiary Charles University)
- Research of key soil-water ecosystem interactions at the SoWa Research Infrastructure (provider MEYS, beneficiary Biology Centre of the Czech Academy of Sciences)
- Effect of global changes on fungal biogeography and ecosystem functioning (provider GA CZ, beneficiary Institute of Microbiology of the Czech Academy of Sciences)
- Response of microbial communities to changing climate in Arctic tundra soils (provider GA CZ, beneficiary Institute of Microbiology of the Czech Academy of Sciences)

- Management of forest genetic resources under climate change (provider TA CZ, benefiriary Czech University of Life Sciences in Prague)
- Optimization of silviculture procedures for adaptation of forest ecosystems to climate change (provider MoA, chief beneficiary Forestry and Game Management Research Institute)

The above projects are described in more detail in Annex 4.

8.4 Information on selected major projects involving international cooperation

International projects include:

- ***ACTRIS***

The (MEYS) was provider of funding required for the large research infrastructure (LRI) ACTRIS-CZ (LM2015037 project). The chief beneficiary was Czech Hydrometeorological Institute (CHMI). RECETOX of Masaryk University in Brno, Institute of Chemical Process Fundamentals AS CZ and CzechGlobe cooperate on the project. Project ran from 2016 to 2019. Currently the MEYS is provider of funding required for continuing LRI ACTRIS-CZ as the LM2015037 project. The chief beneficiary and the participants remained the same. Project has been implemented from 2019 to 2022.

The ACTRIS Czech Republic (ACTRIS-CZ) research infrastructure forms a unique platform for the long-term background air quality monitoring and research closely related to climate, environmental and health issues qualified as society challenges. The RI represents a national node of the existing European ACTRIS RI (Aerosol, Clouds and Trace gases Research Infrastructure) established with support of the EU 7th Framework Programme INFRA-2010-1-1.1.16 (EU FP7). Currently ACTRIS RI activities are supported by the ACTRIS IMP project, which is an EU Horizon 2020 Coordination and Support Section (grant agreement No 871115) as ACTRIS entered the Implementation phase in January 2020. In December 2015 ACTRIS was adopted on the ESFRI roadmap 2016 for Research Infrastructures. From 2015 to 2019, ACTRIS RI activities were supported by the ACTRIS-2 project of EU Horizon 2020 (H2020-INFRAIA-2014-2015: Integrating and Opening Existing National and Regional Research Infrastructures of European Interest). The ACTRIS PPP (Project Preparatory Phase) project, that was crucial for implementing ACTRIS RI into a fully operational pan-European Research Infrastructure, ran from 2017 to 2019. In 2021 ACTRIS was granted the status of ESFRI Landmark as a result of successful submission of the European Research Infrastructure Consortium (ERIC) Step 2 application.

The national ACTRIS-CZ RI is based on the long-term collaboration of 4 research partners: Czech Hydrometeorological Institute (CHMI), The Institute of Chemical Process Fundamentals of the CAS (ICPF), The Global Change Research Institute of the CAS (GCRI) and Masaryk University (MU) at the research facility of the Košetice Observatory (OBK) operated by the CHMI. The core part of the RI is a background station, established in 1988 and continuously operating since then. Essential is the coordination with the ICOS (Integrated Carbon Observation System) activities. The RI is closely connected to capacities of the accredited laboratories of two partners (CHMI and RECETOX). The RI provides an access to the RI equipment. The user community is also entitled to an access to various data sets and products including standard operation procedures, calibration results, data protocols, and support to environmental policies. ACTRIS-CZ users include the individual researchers or students, organizations and institutions as well as general public. The development of ACTRIS-CZ RI is planned both in line with the long-term goals of the European ACTRIS and the national partners. The strategic aim of ACTRIS is to secure long-term coordinated aerosol, cloud and trace gas observations and ACTRIS services in Europe and to guarantee sustainable resources and feasible governance for ACTRIS operations both at national and European level through an internationally competitive European ACTRIS RI.

- ***CzeCOS***

The (MEYS) was a provider of funding required for the LRI CzeCOS (LM2015061 project). The beneficiary was Global Change Research Institute of the Czech Academy of Sciences. Project ran from 2016 to 2019. Currently MEYS is a provider of funding required for continuations of the LRI CzeCOS under the LM2015061 project. The beneficiary remained the same. Project has been implemented from 2019 to 2022.

The research infrastructure CzeCOS is a unique platform for undertaking comprehensive international interdisciplinary research on Global Change (GC) and its impacts on ecosystems. It substantially contributes to the fulfillment of international commitments of the Czech Republic in the field of research, adaptation and mitigation of Global Change impacts. As for the Czech Republic, CzeCOS is the only national component of the following European Research Infrastructures ICOS (Integrated Carbon Observation System), AnaEE (Analysis and Experimentations on Ecosystems) and EUFAR (European Facility for Airborne Research. CzeCOS is also an active member of eLTER RI (Long-term research on ecosystems, critical zones and socio-ecological systems) and DANUBIUS RI (International Centre for Advanced Studies on River-Sea Systems).

ICOS established the European Research Infrastructure Consortium (ERIC) in 2015. ICOS has participated in and coordinated several important projects such as ENVRIplus, which was an EU Horizon 2020 project, that ran from 2015 to 2019. Its subsequent, ENVRI-FAIR project, runs from 2019 to 2022. ICOS ERIC coordinated the RINGO project (Readiness of ICOS for Necessities of Integrated Global Observations) from 2017 to 2020 and currently coordinate the PAUL project (Pilot Applications in Urban Landscapes) that has received funding from the European Union's Horizon 2020 Research and Innovation Programme (grant agreement No 101037319). AnaEE was acknowledge as ESFRI Landmark in 2021. Currently in the Implementation Phase, AnaEE submitted the European Research Infrastructure Consortium (Eric) Step 2 application in 2021 and was recognised by the European Commission as a consortium on 22 February 2022. The DANUBIUS-RI received feedback from the European Commission in 2021 after the submission of a step 1 application, and the request of the members to establish the DANUBIUS ERIC, the step 2 application is expected in 2022. The eLTER Research Infrastructure has been on the ESFRI Roadmap since 2018. It is currently in the preparatory phase, thus on its way to becoming a fully-fledged research infrastructure.

At the national and international levels, CzeCOS offers a unique interconnection between experimental devices for the manipulation of major environmental factors – MANIPULATION EXPERIMENTS, devices measuring physiological changes in ecosystems - PHYSILOGICAL FIELD TOOLS, analytical platform for studying metabolic processes - BIOCHEMICAL LABORATORY, ecosystem stations monitoring greenhouse fluxes emissions - OBSERVATORY FACILITIES and the advanced platform for remote sensing of ecosystems - FLYING LABORATORY. The research infrastructure CzeCOS represents a unique set of both stationary and mobile devices, instruments and other supporting facilities for the research on the GC impacts on ecosystems, the study of adaptation mechanisms in plants and microorganisms and the subsequent development of procedures for mitigation measures. Interdisciplinary and synergetic interconnection of the specific analytical devices, equipment for ecophysiological measuring, equipment for laboratory and field manipulation experiments, bioreactors for the research and development of photosynthetic microorganisms, ecosystem stations for the study of the matter and energy fluxes, as well as high-end sensors for remote sensing of ecosystems allow us to perform comprehensive research on the GC at an international level.

- ***CENAKVA***

MEYS is the provider of funding required for the LRI CENAKVA (LM2018099 project). The chief beneficiary is University of South Bohemia in České Budějovice. The project has been implemented from 2019 to 2022.

CENAKVA is an open institution that serves as a unique centre of knowledge, science, services and education in the field of fisheries and water protection. CENAKVA allows for research of the impacts of global changes on aquatic ecosystems which has a strong application for the practical life of humans. CENAKVA aims to lead the expansion of sustainable aquaculture for environmentally friendly fish production in the Czech Republic and Europe so as to maintain good water quality. CENAKVA aquaculture practices minimal water and energy consumption, minimal negative environmental impacts and minimal waste production. It collects information on the effect of foreign compounds in Central European waters, under conditions of real ecosystems. This information is used in strategic planning in the areas of water conservation, wastewater management and drinking water treatment. The outputs of CENAKVA are also used by foreign institutions, such as World Aquaculture Society, European Aquaculture Society and World Sturgeon Conservation Society. At the national level, CENAKVA cooperates with the Ministry of Agriculture, the Ministry of the Environment and the Czech Fishing Association.

- ***SoWa***

The MEYS was the provider of funding required for the LRI SoWa (LM2015075 project). The chief beneficiary was Biology Centre of the CAS. The project ran from 2016 to 2019.

SoWa aims to facilitate the research of complex interactions between soil and water ecosystems from microscale to the catchment level, with particular emphasis on systems under anthropogenic pressure. The research infrastructure primarily supports research activities aimed at understanding mechanisms and processes responsible for determining key ecosystem processes and services on the catchment level, such as water runoff and purification, nutrient flow in the landscape, decomposition and nutrient release, or key biological processes. SoWa also assesses interactions between ecosystem processes and services following large artificial disturbances. SoWa provides analyses, methodological background and expert knowledge in the fields of soil biology, hydrobiology, nutrient fluxes and cycling in ecosystems, and the modeling of their interactions.

SoWa produces outputs leading to the improvement of ecosystem services, especially in the areas of land restoration, cleanup and decontamination, clean water supply for drinking water production and other uses, flood protection, land use management for sustainable agriculture and forestry, nature conservation and the provision of ecosystem services (including mitigation of global change).

8.5 Systematic observation

Systematic observation, which is directly connected to the subject of climate change, is provided mainly through the Czech Hydrometeorological Institute which, in connection with Act No. 219/2000 Coll., on the property of the Czech Republic (as amended) and acts thereof in legal relations, and according to the founding document of the Ministry of the Environment of 2004, acts as the central State institute for the areas of air quality, hydrology, water quality, climatology and meteorology.

Its activities also encompass establishment of a state monitoring and observation network for monitoring the quantitative and qualitative condition of the atmosphere and hydrosphere and the causes leading to their pollution and damaging, processing of the results of the observations, measurements and monitoring while complying with the principles of the legislation of the European Union, creation and administration of databases for the field and provision of up-to-date information on the state of the atmosphere and hydrosphere, including forecasts and warnings related to dangerous hydrometeorological phenomena.

In the sense of its authorization and in connection with climate change, CHMI acts as the national communication centre in the World Weather Watch system coordinated by WMO, as the authorized professional entity for determining and evaluating the state of surface and groundwaters, the authorized professional entity for drawing up the hydrological balance, the meteorological calibration laboratory and as the flood forecast service.

A good database and its administration form the fundamental basis for all activities connected with protection of the climate of the Earth. The developed countries, including the Czech Republic, are working on development and improvement of modern databases, permitting integration of the available methods of observation and their coordination with similar activities on an international scale.

The programme database of the CLIDATA[38] system was created through cooperation between CHMI and ATACO s.r.o. in Ostrava and has been highly praised by WMO. The Czech CLIDATA programme system is based on the Oracle database environment. It enables users easy transition from older database systems, especially the internationally used CLICOM system. Work with the CLIDATA system is lucid and comprehensible, but is protected against unauthorized access to the application. One of the main objectives in creating this system was maximum safeguarding of information contained in the database. It allows connection of the database with the Geographic Information System, statistical packages and other applications. The CLIDATA programme system was developed so as to enable simple creation of language mutations. CHMI uses CLIDATA for the following activities:

a. Metadata administration pertaining to meteorological, climatological and precipitation (including foreign) networks used by CHMI. This includes information on geographical location of stations, including their history, defining linkages between individual stations and previously used systems of station record-keeping, administrative classification of

38 https://www.clidata.cz

individual measurement points, definitions of the content of measurements in individual stations (measured elements, instruments used and time schemes from a single minute to monthly records) and description of measurement points and their graphical documentation (historical plans, photographs).

b. Administration of descriptive metadata (calculation methods, control mechanisms, importing methods, historical units, element tables and meteorological events, river basins, districts and other).

c. Acquisition and control of data, definitions of acquisition forms in line with current and historically used reports, definitions of control procedures in line with national requirements. Data verification during acquisition and imports, user control based on element and time consistence of data, spatial data control in Geographic Information System.

d. Archiving of climatologic records of the Czech Republic since 1775.

e. Calculation of derived climatologic data and characteristics (interval data, daily, decade, monthly and annual values, long-term averages and extremes, normal values).

f. Calculation and preparation of special climatologic products (wind rose, precipitation intensity, typical days, numbers of event days and more).

g. Preparation of data sets for forecasting and warning services (SIVS) and for evaluations in meteorology and climate sector (dealing with the regular and ad hoc agenda and requests for the meteorological and climatological information).

h. Preparation of CHMI web-based products (monthly and spatial reports, graphs of element development in regions, maps).

i. Application includes a section that is designated for work with phenological data (FENODATA), Aerosounding data (ADATA) and a section that cooperates with hydrological forecasting models (SOMDATA).

In connection with the increasing weather extremes and their manifestations in recent years, the warning system has been further improved on the basis of the innovated Integrated Warning Service System in the Czech Republic. This system includes forecast warning information on 26 dangerous phenomena and for each phenomenon is considered a danger level (low, medium, extreme). Information on the occurrence of dangerous phenomena is issued for five phenomena with extreme levels of danger[39]. A large number of stations with operative presentation of measured data and forecasts, including flash flood indicator system, have been placed on the web site of the reporting and forecasting flood service [40].

In the framework of the Global Climate Observing System (GCOS), the Czech Republic participates only in meteorological atmospheric observations GCOS: in the network of GSN round-level stations at the Milešovka observatory, in the GAW network at the Hradec Králové CHMI Solar and Ozone Laboratory and at the CHMI observatory for monitoring the quality of

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39 https://portal.chmi.cz/files/portal/docs/meteo/om/sivs/sivs.html

40 https://hydro.chmi.cz

the natural environment on a regional level, located in Košetice[41]. All three observatories adhere to the principles of climate monitoring introduced in GCOS/GOOS/GTOS.

CHMI operates Brewster photospectrometer at Iceland since 2021, which was relocated from its previous deployment in Antarctic.

The Czech Republic is a member of the Intergovernmental GEO – *Group on Earth Observations*. The programme of GEO encompasses the GEOSS programme – *Global Earth Observations System of Systems*. The Czech Republic is actively involved in the EU Copernicus, which represents the EU contribution to the global GEO program. The main objective of Copernicus is to ensure a continuous, independent and reliable access to data and information from the Earth observations for the EU.

The Czech Republic became the full member of the EUMETSAT on 14. 4. 2010 after ratification of the Accession Agreement between EUMETSAT and the Czech Republic which was signed on 22. 6. 2009. Information from meteorological satellites are in the Czech Republic considered as a one of the fundamental sources of forecasting and warning system. CHMI also operates, in cooperation with the Czech military hydrometeorological services, the Integrated Warning Services System where the satellites data are crucial.

The CHMI observatory in Hradec Králové acts as the European Dobson spectrophotometry calibration centre and, together with the Slovak Hydrometeorological Institute, is also active in the area of measuring ozone and solar radiation levels.

In 2007, the Czech Republic became a co-working member of the METEOALARM project of the EUMETNET (Network of European Meteorological Services organization. The project, which is available at the website [42], provides a rapid survey of warnings against dangerous meteorological phenomena in Europe.

The WMO always appreciates the Czech foreign assistance provided to developing countries in meteorology and hydrology as this assistance is being requested more and more in connection with building up climate-related databases[43,44], where the CLIDATA system is currently at the cutting edge of available technology worldwide. By virtue of the system flexibility, easy administration and multi-language support, the system is capable of set up in any foreign country and for any meteorological service. National meteorological services in 35 countries all over the world (e.g. Guyana, Georgia, Ethiopia, Nigeria, Jamaica, Latvia, Lithuania, Serbia, Montenegro, etc.) use the CLIDATA system.

41 CHMI Annual Report 2015, CHMI, Prague 2016

42 https://www.meteoalarm.org

43 https://www.clidata.cz

44 www.wmo.int

9 ENVIRONMENTAL EDUCATION AND PUBLIC AWARENESS

9.1 General policy

The obligation to promote environmental education and public awareness (EE&A) arises from valid legislation, the fundamental statute being Act No. 123/1998 Coll., on the right to information on the environment awareness and Act No. 561/2004 Coll. on School Education.

The most important body regarding education for sustainable development is The Government Council for Sustainable Development of the Czech Republic (Council). It was established by Government Resolution No. 778/2003 as a permanent consulting, initiative and coordinating body of the Government of the Czech Republic for the area of sustainable development and strategic management. In order to foster partnership and inform all stakeholders about the latest developments in the field of sustainable development, the Office of the Government has revived the tradition of the national Sustainable Development Forum, which is held annually since 2014. The Forum in 2015 was one of the first opportunities to discuss the implementation of the SDGs on the national level after their adoption. The Council established the Working Group for education for sustainable development.

The framework for the SDGs implementation in the Czech Republic has been established by the adoption of the Government Resolution on January 25, 2016, which tasked the Prime Minister in cooperation with the Minister of Environment to put forward a proposal for implementation of the SDGs on the governmental level. The resolution has been adopted after a series of consultations between the Government Office, the Ministry of Foreign Affairs and the Czech Statistical Office.

The main implementation platform of the Agenda 2030 in the Czech Republic is the strategic framework *Czech Republic 2030* (prepared by the Sustainable Development Unit of the Government Office) and was approved by the Government in 2017.

The document sets out goals and targets to be accomplished by the 2030 and consists of a detailed development analysis and strategy for sustainable development that should be reflected in all sectoral and regional strategies. It outlines six national priority areas (people and society; economic model; resilient ecosystems; municipalities; global development; and good governance). Another segment of the document consists of an impact analysis of global megatrends on national development.

To ensure successful implementation, the SDGs must be perceived in wider context than development cooperation or climate change and new actors must be involved in the process. The Czech Republic considers as key principle for success building strong global partnership based on participation all relevant actors and mobilization of all required financial and nonfinancial resources.

The above documents that are broader in their scope are complemented by specific EE&A strategies, which include:

- The State Programme of Environmental Education and Eco-counselling of the Czech Republic for 2016–2025 (last novelization by Government Resolution No. 652/2016) implemented by Action Plan for 2019–2021 and for 2022–2025 period.

Key documents in terms of school environmental education and awareness include:

- Individual framework education programmes, which should introduce environmental education as a compulsory cross-cutting subject for all types and levels of schools.

The regions have become important actors in EE&A in recent years, where each region formulates their own EE&A concepts and funding mechanisms.

The topic of environmental changes is described in the introduction to the Strategy of the Czech Republic's educational policy up to 2030+ (S2030), which deals with the topic of sustainability and environmental education: "Equally important are the environmental changes we are currently facing. Climate change, declining biodiversity, growing air and water pollution, ever-increasing consumption of non-renewable resources and a declining resource base are making a significant contribution to changing the environment in which we live."

Environmental education is mentioned in Strategic Objective 1, in the field of Civic Education. Strategic line 1 (change of content, methods and forms of education) also mentions environmental issues within the need to modernize the content of the curriculum, the need to develop students' critical thinking, understanding of entrepreneurial principles and environmental issues and the need to use educational programs of other institutions - those that provide education about environmental issues.

Important part is also education for sustainable development, which aims to equip the citizen with competencies (knowledge, skills and attitudes) to socially and environmentally responsible behavior (behavior responsible to nature and people).
The area of sustainable development, its cross-cutting reflection and consideration in the forms and methods of education is a necessary prerequisite for understanding the interconnectedness and interrelationship of economic, social and environmental aspects of development, at local, regional, national and global levels.

Environmental issues must also be taken into account, when adapting to labor market transformations and supporting further education.

9.2 The State Programme of Environmental Education and Eco-counselling of the Czech Republic for 2016–2025

The State Programme of Environmental Education and Eco-counselling for 2016–2025 (SP EE and EC)[45] is a key national strategy of the Czech Republic for the field of environmental education and eco-counselling (EE and EC), defining a structured vision, strategic areas,

45 https://www.mzp.cz/cz/statni_program_evvo_ep_2016_2025

objectives and measures, the implementation of which includes not only state administrative authorities, but also regions, municipalities, schools, including universities, specialised facilities such as ecological education centres and eco-counselling organisations, and other entities established by the public administration, as well as private non-profit organisations, educational and research institutions, museums, zoos, botanical gardens, forestry institutions, libraries, church facilities, etc. SP EE and EC constitutes methodological support for drawing up regional and municipal environmental education and eco-counselling concepts and evaluating the impact of all forms of such activities at all levels.

The obligation of the Ministry of the Environment is to draw up and coordinate the State Programme and submit it to the government for approval stems from the Act No. 123/1998 Coll., because information about the environment available in this resort. Implementation is primarily supported by the state budget (in particular the Environment and Education Ministries), national fund calls for applications (in particular the State Environment Fund) and EU cohesion funds.

The state programme stems from and builds on a broad spectrum of legislative and programming documents, from international, governmental and local level. From an international perspective, this includes primarily the following documents:

- the Paris Agreement became the most important milestone of international climate policy, referring to education, training, public awareness, public participation and access to information under Article 12
- the Sustainable Development Goals (SDGs), approved by the UN member states in September 2015, which includes Goal 4 "Quality Education", which includes target 7 – by 2030 ensuring that all learners acquire the knowledge and skills needed to promote sustainable development, including, among others, through education for sustainable development and sustainable lifestyles
- the Global Action Programme on Education for Sustainable Development, adopted at the 37th UNESCO General Conference (2013), which includes both sustainable development and environmental education (see point 5g)
- the UNECE Strategy on Education for Sustainable Development (2005)
- Directive 2003/4/EC of the European Parliament and of the Council of 28 January 2003 on public access to environmental information, which emphasises the role of public authorities in public awareness and environmental issues
- the European Landscape Convention (adopted by the Council of Europe in 2000 – CETS No. 176), as one of the few documents emphasising a holistic view of the environment
- the Aarhus Convention on access to information, public participation in decision-making and access to justice in environmental issues (1998), which enshrines the commitment to support environmental awareness and public education.

One of the key topics of the SP EE and EC is “Climate in context”. Climate change is a relatively new topic from the perspective of the long-term development of environmental education (in the Czech Republic and elsewhere). To date it has not become an integral component of the understanding of natural, social and economic conditions for life on Earth and in the contemporary world, nor has it been sufficiently incorporated into the educational system (in contrast to the older and more socially accepted "environmental protection"). For this reason, it is necessary to focus on incorporation of this topic to the EE and EC system, with a quality and urgency corresponding to the fact that climate change is considered as one from the greatest contemporary global threats, by making appropriate didactic use of scientific findings and drawing up methodologies and programmes aimed at all important target groups.

The main goal is to address all important targeted groups to understand the causes of climate change and their negative effects and impacts on the Czech Republic, Europe and the world and the ability to learn and implement measures for both mitigation (reducing greenhouse gas emissions and especially moving away from fossil fuels) and adaptation (adapting to the negative impacts and consequences of climate change, especially reacting to extreme weather events).

The State Programme is increasingly focusing on climate education in its implementation Action Plans for 2019-2021 and 2022-2025 period. State support goes and is planned to go mainly to eco-centers and to schools.

Schools are encouraged to adapt their lands to natural gardens. The last prepared national call will focus specifically on the support of climatic gardens, i.e. gardens that include adaptation and mitigation elements and at the same time suit education on the topic.

In eco-centers, thanks to the support of more and more educational and awareness-raising programs for schools and the public focused on aspects of climate change provided by non-profit organizations, especially ecological education centers. Within the Czech Republic, these centers continuously offer more than 60 educational programs focused on the topic of drought, water, climate change. Here are some important projects and programs, their complete overview is then in the appendices:

- CO2 League - the aim of the project is to motivate pupils and students to increase their efforts to protect the climate, through a multi-level assisted program that helps identify and implement local (school/city) projects on the topic.
- Environmental education program The city's builders (from Ekocentrum Koniklec) belong to the programs on the adaptation of settlements to climate change. With the help of a simulation game, students get acquainted with all climatic phenomena and their effects on the urban part where they live. Subsequently, students in the field try to find measures for the surroundings of their school against these phenomena.
- People in Need has been offering the Climate Change Online Course since 2020, which was created for teachers of all subjects who want to learn about climate change and are looking for information and methodological support for their own teaching.

It was crucial in the given period that the Ministry of the Environment supported the establishment of the Working Group for Climate Education, which was approved on 6 February 2020 as a part of ESD Comittee. Its coordination was in charge of the Ministry of the Environment and its goal was to create a policy paper for the integration of climate education in the education system in the Czech Republic and methodological recommendations and examples of good practice for educators to address climate change in teaching. The working group had about 25 members, mainly from the ranks of educators and researchers, but its members also include representatives of students and psychologists.

After a year of work, the main output of the group was the publication „**Climate is changing – and what about us?**“ which brings scientific research-based recommendations for the development of climate education. The publication was published by the Ministry of the Environment in a quantity of 6,000 copies and is available also online - https://www.mzp.cz/cz/zmena_klima_publikace.

The main recommendations for formal/school education in the publication are as follows:

1. Recognize climate education as a priority
2. Incorporate the topic of climate change into the Framework Educational Programs
3. Support teachers in the implementation of climate education
4. Ensure quality materials and effective programs for teaching about climate change
5. Coordinate the strengthening of the capabilities of all Czech citizens to participate in climate protection (such as ACE programms etc.)

Therefore, in the coming years, the Ministry of the Environment feels that climate education is not only a high priority within EE and its goal is not only to support the development of methodologies and program implementation but also to support the implementation of climate education within the education system.

Action Plan for the years 2022-2025 to the State Program of Environmental Education and Awareness and Environmental Counseling for the years 2016-2025 (AP EE&A)

AP EE&A 2022-2025 is another important document in the field of environmental education. It was developed in cooperation with the Ministry of the Environment and approved by the government at the end of 2021. It contains a number of specific activities that aim to improve environmental education:

- Motivation of NPI and other organizations to be authorized for the professional qualification "specialist in the field of environmental education"
- Staffing of the EE&A agenda also with regard to the CZ PRES presidency (in the form of embedding the topic in the description of the work of persons at the Ministry of Education, Youth and Sports and NPI)
- Continuation of the CSI survey in the field of Environmental Education and collecting examples of good practice in primary schools
- Preparation of the announcement of personalities and organizations for the extraordinary contribution of EE&A
- Evaluation of EE&A plans and preparation of other strategic documents in this area
- Thematization of Environmental Education in the Long-Term Plan of Education and Development of the Education System of the Czech Republic 2023-2027

- Non-investment support focused on development and education in specialized EE&A programs within the ESIF, support for education and activities in the field of EE&A in the calls of planned interventions OP JAK
- Cooperation with the Ministry of the Environment on the guarantee of the TAČR project - Tools for increasing the share of outdoor teaching and contact with nature within primary and secondary education
- Ensuring the dissemination of valid methodological materials through methodological portals
- Motivation of NGO workers for education in the field of EE&A, support for linking formal and non-formal education within EE&A
- The use of cultural and natural heritage in education on environmental issues
- Support for the Globe project, the possibility of sending teachers on internships abroad
- Methodological and information meetings at NPI workplaces or ecocentres, or regional authorities
- Creation of teaching materials emphasizing the goals and topics of EE&A
- Motivation of the founders to create suitable conditions for teaching in the field
- Support for NGOs focused on youth work in the field of non-formal education
- Support for locally embedded learning through OP JAK projects, consideration of locally embedded learning in FEP revisions
- Creation of teaching materials emphasizing the topics of sustainable consumption in accordance with the revised curriculum
- Supporting universities to implement sustainable campuses
- Efforts to implement the recommendations proposed by the PS for climate education
- In cooperation with the Ministry of the Environment regarding training for school principals in the area of decarbonisation and careful operation of school infrastructure

9.3 Education system

EE&A is a part of the National Programme for the Development of Education in the Czech Republic – the so-called White Paper (2001)[46]. One of the main provisions of the programme consists of education on environmental protection in the sense of providing for sustainable development in society. The Act on Schools of 2004 stipulates acquiring knowledges on the environment and its protection based on the principles of sustainable development as one of the components of a general education. The Strategy of Lifelong Learning, adopted in 2007 by Government Resolution No. 761, mentions, in the main strategic directions, social partnership, intended to promote harmonization of educational opportunities with the needs of economic, environmental and social development and also contains proposals for measures that emphasize sustainable development. The long-term plan for education and development of the educational system in the Czech Republic contains proposals for measures emphasizing sustainable development and describes the reasons for the reform steps in education, based, amongst other things, on the role of education as a guarantee of sustainable development.

46 http://info.edu.cz/en/node/415

Environmental education is a cross-subject theme in national curricula for primary and secondary schools. This means that all schools must incorporate, in one way or another, EE to their work with children. Advice on how to develop EE at schools is elaborated in more detail in the Recommended Learning Outcomes for Environmental Education which covers the areas of environmental sensitivity, principles, problems and issues, inquiry skills and action strategies.[47]

As for preschools, a national network called the Mrkvička (Little Carrot)[48] which has been in place since 2007 for kindergartens that are interested in EE&A (approximately 829 kindergartens in all regions of the Czech Republic). The objective of the project is to implement modern environmental education in kindergartens and provision of up-to-date information and guidelines for kindergarten teachers. A wide range of environmental educational programmes of environmental education centers is available for kindergartens.

The reasonable progress has been made with forest kindergartens in the Czech Republic recently. This type of preschool education with close contact with the nature is currently very popular, there are more than 120 forest kindergartens, founded in the last 6 years. Some of them become even enrolled in the register of the Ministry of Education, in the beginning of the 2017. In March 2016 the Czech Parliament agreed on a forest kindergarten definition: "The status of forest kindergarten can be used by those kindergartens, which organize their educational process mainly in an outdoor area, outside the shelter of a kindergarten. The kindergarten's shelter is used only for an occasional stay. The shelter of a forest kindergarten mustn't be a building".

Education focused on sustainable development and environmental issues is part of the Strategy of the Czech Republic's educational policy up to 2030+. This area is also being addressed in the Environmental Education Action Plan for 2022-2025 (AP EE&A), for more information see chapter 2 above.

9.3.1 Elementary education

Several hundred elementary schools interested in EE&A are associated in the M.R.K.E.V. network or the Environmental Education Club and in a number of school environmental projects. The best known include the Eco-school project (Tereza Association) and the School for sustainable life (Partnership Foundation and SEVER – Centre of Environmental Education and Ethics). A wide range of aids, publications and also environmental educational programmes provided by lecturers from environmental education centres are available for elementary schools. These are either short programmes for several teaching hours or several days long with accommodation in the centres.

Approximately 700 primary schools interested in EE&A are associated in the M.R.K.E.V. (Methodology and implementation of complex environmental education) and other schools in the Club of Environmental Education and in a number of school environmental projects. Among the best known are the Ecoschool project (Tereza Association) and the School for Sustainable Living (Partnership Foundation and NORTH - Center for Ecological Education and Ethics). There is a wide range of aids, publications and environmental education programs available for primary schools, which are provided by lecturers from environmental education

47 http://www.nuv.cz/vystupy/doporucene-ocekavane-vystupy-1

48 http://www.pavucina-sev.cz/rubrika/71-PROGRAMY-MRKVICKA/index.htm

centers. These are either short programs for several lessons or multi-day accommodation with accommodation in the centers. The National Pedagogical Institute has published methodological and information support for schools in the form of digifolia on the methodological portal www.rvp.cz.

9.3.2 Secondary education

The Ministry of Education, Youth and Sports issues so called “Framework Educational Programmes” for 2 secondary academic education levels (gymnasia) and 283 high schools in three stages. Gymnasia curriculums include in their SEPs cross-cutting topic “Environmental Education” and all secondary vocational levels include “Man and the environment”. There are 26 secondary schools that even have professionally focused curricula focused on the protection of the environment. These include topics such as “Ecology and the environment,” or “Industrial ecology.”

Climate change education is part of the recommendations for online teaching of the National Pedagogical Institute of the Czech Republic (https://projekty.npi.cz/strategicke-rizeni/343-informace-projektu-srp-v-nouzovem-stavu/2054-tipy-na-on-line-vyuku-pro-reditele-ucitele-i-rodice).

9.3.3 University education

Over 100 fields of study at universities are available at bachelor, masters and post-gradual levels which are focused on EE&A. EE&A as a part of mandatory-optional, or purely optional or selective courses in university departments involved mostly in public administration, civic sector, regional policies, agriculture or architecture. EE&A courses are being taught at almost all public universities (expect art schools) and at several private universities.

An electronic web encyclopaedia “Enviwiki” (http://www.enviwiki.cz) has been created to support education of all students not just for the benefit of future pedagogues. The Centre of environmental studies has been publishing its own electronic magazine for environmental education “Envigogika” since 2006.

The Environment Center at Charles University initiated establishment of a “Forum of University Teachers: Education for sustainable future”. The objective of the Forum is to contribute to clarification and generation of content, scope and methods of education for sustainable development and to ensure mutual awareness, promote cooperation in preparation of courses, lectures and teaching materials, research and project work.

The movement “Univerzity za klima” (Universities for Climate) was originated in 2019 as a response on the wave of high school climate strikes called “Fridays For Future”. Members are both students and academic staff who think universities should be more active and take a leading position in fight against climate changes. The movement is connecting groups from universities all around the Czech Republic – e.g. in Ostrava, Prague, Zlín, Brno or Olomouc.

EE&A is also a part of objectives stipulated by the Strategy for Education for Sustainable Development in the Czech Republic (2008-2015), approved by the Government on 9 July 2008 and in Action plan to the Strategy (specific measures for 2011 and 2012), approved on 23 February 2011, in university education sector.

Topic of EE&A is also a part of strategic documents and programs supporting development of the Czech Republic such as The Strategic Plan of the Ministry for Higher Education for the period from 2021 (SP2021+), Recovery and Resilience Plan for Czechia or annual Centralized Development Program. These programs provide financial support for universities for their own and with other universities shared projects in selected topics.

Within SP2021+ is EE&A part of the first priority objective “Develop competencies directly relevant to life and practice in the 21st century” which means EE&A is seen as of the crucial areas of life in 21st century. Also in other types of programs is EE&A among main topics and supported areas. In Czechia`s Recovery and Resilience Plan are environmental quality, waste management or power engineering among supported topics called progressive fields and program should lead to the development of new study programs in these fields.

9.3.4 Further education of pedagogical workers

Further education of pedagogical workers is also an important area. The Ministry of Education, Youth and Sports is responsible for integration of the elements of environmental education and awareness into the post-graduate education of pedagogues. A number of NGOs and educational facilities offer certified EE&A seminars and courses for pedagogues lasting from several hours to several dozen hours.

Environmental Educator has recently become one of the professions in the National Register of Qualifications(https://www.narodnikvalifikace.cz/en-us/qualification-1009-Environmental_education_officer). It enables people to prove their competences and receive an official qualification degree. However, there is no experience with the process so far.

There are various forms of further education for teaching staff. Teachers training focuses on methodological assistance for teachers in planning, implementing and evaluating environmental education at schools, as well as providing practical guides and teaching methods for classes, expertise on ecology, the environment and environmental protection and a forum for teachers to swap experiences with environmental education.

The new standard for studying specialised activities in the field of environmental education was issued by the Ministry of Education, Youth and Sport in 2015. The standard stipulates that specialized studies must include at least 250 hours of instruction. Of the total number of teaching hours, no more than 20% can be used for distance learning, i.e. e-learning.

It is worthy to mention also Local Agenda 21 - a voluntary tool for sustainable development at the local level. Within its framework, the processes of analysis of the current state in the area of adaptation to climate change are set in a systematic manner; the basic preconditions are elaborated into local adaptation strategies. The expert evaluation, which is financed by the Ministry of the Environment, is based on measurable indicators and recommends further action. Examples of good practice can be used by cities/municipalities in the highest categories (in 2022 it was 7 municipalities), dozens of other cities are analyzing their situation and are interested in expert cooperation. Within Local Agenda 21 system also education for sustainable development is in progress, where climate change and adaptations are one of the important topics.

Link provided here leads to web with information about accredited programs of further teachers education: https://www.msmt.cz/vzdelavani/dalsi-vzdelavani/databaze-akci-dvpp (institutions such as Lipka, KEV, Líska, etc. focus on environmental education)

Following link is a database of accredited programs of our directly managed organization NPI CR: https://dvpp.msmt.cz/advpp/dvppv.asp

We would also like to inform you that in 2015 the Standard of Specialization Studies was updated to perform specialized activities in the field of environmental education (https://www.msmt.cz/vzdelavani/dalsi-vzdelavani/standardy-a-metodicka-doporuceni) to perform specialized activities in areas of environmental education, in which, among other things, this issue of the threat of climate disruption is also elaborated, specifically see point - knowledge competence in the fields of ecology and environmental studies.

9.3.5 Informal education

The education system (and thus also EE&A) encompasses both activities taking place at schools and educational facilities (formal education) and also in employers' facilities of, private educational institutions, NGOs, school facilities and other organizations (non-formal education), as well as unorganized, every-day experience and activities at work, in the family, during free time, interactions with society and nature and through the influence of the media (informal learning).A wide range of extracurricular education for children and young people is available, with participation of numerous of school institutions and NGOs.

NGOs also play an important role. Greenpeace, the DUHA Movement, Centre for transport and energy, the CZ Biom Association and others are systematically involved in climate change-related public debates, workshops or seminars.

Specific support for EE&A related to climate change is also provided by some important foundations, such as the Partnership Foundation, the Foundation for the Development of a Civic Society, the Via Foundation and the Open Society Fund, Heinrich-Böll-Stiftung and also regional foundations – for example, the Foundation for the Jizera Mountains and the Community Foundation of Ústí nad Labem.

Governmental institutions in the area of the environment participate in environmental education of the general public – in addition to the Ministry of the Environment (see below), also the Regional Authorities, Administrations of Protected Landscape Areas and National Parks, the Czech Environmental Information Agency (CENIA), the Nature Conservation Agency of the Czech Republic as well as other institutions.

Each year, the Ministry of the Environment opens a tender for projects formulated by civic associations and NGOs. Between 2017 and 2021 the Ministry of the Environment supported a total of 65 projects in EE&A sector focusing on climate change and the total funding amounted to 7,7 million CZK.

In the years 2018 -2021, the Ministry of Education, Youth and Sports supported projects of several non-governmental non-profit organizations (NGOs) within the state support of work with children and youth and non-formal education, which significantly include environmental education and awareness, It was mainly about the support of systematic education in the so-called "NGOs recognized by the Ministry of Education for work with children and youth", which includes the following organizations: Czech Union for Nature Conservation, Young Nature Conservation, Brontosaurus Movement, Junák - Czech Scout. Another of the supported projects was the annual project of the Czech Council of Children and Youth "72 hours". This is a multi-day event to support volunteering, which in the years 2019-2021 was significantly focused on activities related to environmental protection and climate change (tree planting, a call for energy savings, etc.). Furthermore, it is, for example, the educational international project Globe of the organization TEREZA, educational center, z.ú., which is focused on research-oriented teaching and contributes significantly to the interconnection of formal and non-formal education. The amount of support for these projects in individual years can be found at https://www.msmt.cz/mladez/vysledky-dotaci-2.

9.3.6 Examples of supported projects in individual years

2017

Project	Author
Community Renewable Resources - a new model based on co-ownership and self-sufficiency of municipalities and households	The RAINBOW movement - Friends of the Earth Czech Republic
Model climate conferences for young people	Center for Ecological Education SEVER, Horní Maršov, p.b.o.
Climate change on the Ekolist.cz server - information service (not only) for cities and municipalities	BEZK
Smart street lighting	PORSENNA p.b.o.
Nature-friendly forestry and FSC - effective and sustainable adaptation to climate change	FAIRWOOD, r. s.
Reducing energy consumption in social services facilities	EkoWATT, r. s.

2018

Project	Author
Decentralized energy sources - possibilities of adaptation to climate change in the urban environment	The RAINBOW movement - Friends of the Earth Czech Republic
About climate change in the forest and in the wetland	Čmelák - the Society of friends of nature, r.s.
Offset projects: A tool to reduce greenhouse gas emissions and increase land resilience	CI2, p.b.o.
Zelenestrechy.info - web information portal for roof greening	The union of the creation and maintenance of green, r. s.
Revitalizing green courtyards - the way to sustainable cities	Bieno, r.s.

2019

Project	Author
Myths and mistakes - untruths and misinformation in the field of adaptation and mitigation measures	CI2, p.b.o.
Adaptation and mitigation measures for public administration	Nature Conservation Forum
Manual for Mayors - CLIMATE CHANGE I: drought	LAG Czech North
We are counting on water	Ekocentrum Koniklec, p.b.o.
Community Renewables - Today and Tomorrow	The RAINBOW movement - Friends of the Earth Czech Republic

2020

Project	Author
Local climate protection - motivation and education for ambitious goals	VERONICA, r. s.
Careful forest management as a tool for cities and municipalities to adapt to climate change	FAIRWOOD, r. s.
Municipalities for nature and climate protection	Natural garden, z.s.
We involve the public in local adaptation to climate change	Arnika, r.s.

2021

Me, the landscape and the effects of climate change	Brontosaurus movement
The climate is changing and what about me? - for adults and educators	Ekocentrum PALETA, r.s.
School forest and forest grief	Chaloupky p.b.o. and Forest Kindergarten

9.4 Financing

In the Czech Republic EE&A is financed from various sources, the most important sources are the state budget and funds, local government funds (municipality budgets), EU funds, foundations, private funding and own funding of various NGOs.

In terms of funding, important support from EU funds was secured in the past as part of the Operational Programme Environment and the Operational Programme Education for Competitiveness. For example, the OP Environment helped dozens of entities in the Czech Republic to build or renovate eco-centres in 2007–2014 with a total contribution of around CZK 800 million. Currently, support is being prepared specifically for the facilities of eco-centres for the climate education and it is expected to support around 50 of them by amount of approximately CZK 550 million.

The key sources of EE&A funding are currently:

- The National Environment Programme coordinated by the Ministry of the Environment and the State Environment Fund, from which EE&A support is estimated at around CZK 50 million a year.
- Subsidy programme of the Environment Ministry for supporting NGO projects from which projects focused on EE&A are also supported annually at a rate of around CZK 5–10 million.
- The subsidy levels for EE&A from regional budgets vary by region, but range from around CZK 0.5 million to around CZK 10 million.

Approximately 1/4 of these sources is used for climate education projects.

The Technology Agency of the Czech Republic

Several interesting projects connected with climate education and public awareness have been supported by the Technology Agency of the Czech Republic (TA CR) recently, where the Ministry of the Environment is the main user of the outputs.

In the period 2018 - 2021, 39 projects were supported through the TA CR with a total amount of funding € 33.9 million.

In 2019, with the support of TA CR, the project "Determinants and processes shaping the environmental attitudes and behaviour of the Czech Republic" was launched, the aim of which is to understand what people in CR think and how they think about drought and air. From this knowledge, we want to deduce what and how the departmental organizations should communicate to get people to change attitudes and behaviour in practice. Practical recommendations and guidelines should be derived in 2022. The output will therefore be "communication manuals" for drought (water conservation, use of grey water, and landscaping of gardens) and air (heating and passenger transport). Based on the research carried out, they will specifically advise on how the public administration should proceed in communicating drought and air issues.

In 2019-2021, a large survey of the environmental literacy of primary school pupils took place in the CR. In close cooperation with the Czech School Inspectorate, it was carried out by experts from Masaryk University and J. E. Purkyně University. The research took place within the project "Methodological framework for environmental literacy in schools", supported by TAČR. Almost 30,000 sixth, eighth and ninth graders and their teachers took part in the survey. Attitudes towards climate change were a separate area of the survey.

In 2022 TA CR is preparing call for survey, concerning the tools for effective climate education and awareness, which aims to design and validate sub-tools for climate change education and awareness for various target groups (children and youth) by 2024.

The most extensive project is solved within the activities of the Water Research Centre titled "Water systems and water management in the Czech Republic in the conditions of climate change". The project is planned for the period 2020–2026 and is focused particularly on the issues of water management, drought, mitigation of its impact on human settlements, nature and water supply.
Another strategically important project is titled "Climate-energy plan for heating branch in the Czech Republic" The outputs of the research work and methodological guidelines will serve for integration into the overall framework given in the proposal for a Regulation of the European Parliament and of the Council on the governance of the Energy Union.

Climate change also affects international relations. In the period 2021–2022, a research project titled "Geopolitical Impacts of Climate Change" is underway. The aim of the research is to capture, analyze and conceptualize these influences so that it can be adequately reflected in the conceptual documents and practice of the Ministry of Foreign Affairs of the Czech Republic in order to contribute to increasing both global and especially European resilience to the climate impacts.

Specific measures to increase the resilience of cities and municipalities to climate change were provided by the results of the project titled "Identification of locations vulnerable to thermal stress – a tool for sustainable urban planning". It brings a specific set of measures for different types of locations vulnerable to thermal stress.

A project, which is being solved in 2019–2022, titled "Development of effective tools to evaluate and reduce the negative effects of rainfall-runoff processes in the non-growing season in connection with the extremes of climate change" is more conceptually focused.

9.5 International activities

Organizations in the Czech Republic participate in a number of international projects concerned with environmental communication, education, and public awareness. Some of these activities are supported methodically and financially directly by the Ministry of the Environment and Ministry of Education, Youth and Sports.

Below we describe some of the most important:

Model Climate Conference

Model Climate Conference, based on the United Nations Framework Convention on Climate Change, Conferences of the Parties (COP). The model conferences should enthuse and challenge students to think about the national and international implications of climate change.

Environmental center SEVER is actually the coordinator of this project in the Czech Republic.

BEACON

Since 2018, almost 60 schools from Bulgaria, Czech Republic, Romania and Germany have been participating in the *BEACON* project, coordinating in CR by SEVEN. Their aim was to raise awareness of climate change and protection at the individual level. There are a number of activities at schools aimed at different target groups. From creating incentive models for energy savings between schools and their founders to measuring the temperature and CO2 concentration by pupils and teachers directly in the classroom.

The School for Sustainable Development

The School for Sustainable Development programme was conceived and created in 2004 as a joint project of several non-profit organizations, including Groundwork (UK), Partnerstwo dla Srodowiska (Poland), and Nadace Partnerství (Environmental Partnership Foundation) and Středisko ekologické výchovy SEVER (SEVER Centre of Environmental Education) (Czech Republic). The programme is based on the principles of locally anchored and community learning, its joint vision is to support schools as initiation centres of local sustainable development and, at the same time, to use the schools' involvement as an effective tool of education for sustainable development. Practical projects initiated by students and teachers were supposed to trigger systematic improvements of the quality of the environment, as well as other changes toward sustainable development in the life of local communities, and to provide meaningful learning experiences to students. The programme has gradually expanded into other Czech regions, supporting many projects improving the surroundings of schools and public places, mapping or informing about local places of interest or local heritage, or presenting or making use of renewable energy sources, environment-friendly and safe mobility, better waste disposal practices etc.

Eco-Schools

Students work with teachers, school staff and the local public to change and ecologise their schools and improve the environment around them. The basis of the programme is a seven-step methodology that is a simple but effective tool to turn the involved schools into real Eco-Schools. An eco-team is created at the school, which goes through the school literally from the basement to the attic. They conduct an analysis and search for what specifically should be done for the school to become more environmentally friendly. The eco-team members elaborate on their ideas and bring them to their classrooms, where they implement them along with their classmates and adults. They do not neglect to evaluate the implementation.

The GLOBE programme

The *GLOBE* programme is a global programme for schools, which the Czech Republic joined together with other countries in 1995. For the *GLOBE* programme, scientists prepared a system of demonstration measurements that makes easy for students to monitor trends of different global environmental issues. In the *GLOBE* programme, students perform measurements and observations of the quality of the environment in the areas such as meteorology, hydrology, biometry, phenology, pedology and remote sensing of the Earth. They send their observations through the Internet to the NASA center in the USA. The project also includes monitoring the carbon cycle, with participation almost 400 students and dozens of schools.

UNESCO Associated Schools Network

The UNESCO Associated Schools Network (ASPnet) links educational institutions across the world around a common goal: to build the defences of peace in the minds of children and young people. The over 11,500 ASPnet member schools in 182 countries work in support of international understanding, peace, intercultural dialogue, sustainable development and quality education in practice. ASPnet – a driver for innovation and quality in education – is recognized as an effective tool for reaching target 4.7 on Global Citizenship Education (GCED) and Education for Sustainable Development (ESD) of Sustainable Development Goal 4 - Education 2030.

The UNESCO Associated Schools Network has 52 affiliated schools in Czech Republic, the member schools focus on four different areas: global problems and deepening of the UN system, intercultural and multicultural education, human rights and democracy, ecology and environmental issues. An integral part of membership in the ASPnet is also participation in international projects and competitions.

ANNEXES

FIFTH BIENNIAL REPORT OF THE CZECH REPUBLIC

Accompanying the document:
Eighth National Communication
of the Czech Republic
under the United Nations Framework Convention on
Climate Change

1. Introduction

The Fifth Biennial Report of the Czech Republic (BR5) was prepared under Decision 2/CP.17 of the Conference of the Parties to the UNFCCC and was submitted as an Annex to the 8th National Communication of the Czech Republic under the UNFCCC (NC8).

This document is structured according to an outline defined in Annex 1 of the Decision 2/CP.17. Provisions of many chapters are reflecting information already provided in the 8th National Communication of the Czech Republic in its corresponding chapters. Some required provisions were merely referenced pointing to corresponding chapters in the 8th National Communication of the Czech Republic. Although the outlines of Biennial report and National Communication are not completely identical we believe the structural and informational integrity has been retained in both documents.

Tabular information as defined and required by the UNFCCC Biennial report guidelines has been submitted electronically through UNFCCC Application and Network Access Portal.

Abbreviations

To avoid confusion please check abbreviations in the List of Abbreviations of the 8th National Communication of the Czech Republic.

2. Information on GHG emissions and trends

For the information on greenhouse gas emission and trends and the national inventory arrangments refer to Chapter 3 of the 8th National Communication of the Czech Republic. Summary tables of greenhouse gas emissions of the Czech Republic for emission trends by gas and by sector in the common tabular format are presented in the CTF Table 1.

3. Quantified economy-wide emission reduction target

In 2010, the EU submitted a pledge to reduce its GHG emissions by 2020 by 20% compared to 1990 levels. Since this target under the UNFCCC has only been submitted by the EU-28 and not by each of its Member States (MS), there are no specified targets for the individual MS. Therefore, the Czech Republic, as part of the EU-28, takes on a quantified economy-wide emission reduction target jointly with all the EU MS.

The definition of the EU target under the UNFCCC for 2020 is documented in the revised note provided by the UNFCCC Secretariat on the “Compilation of economy-wide emission reduction targets to be implemented by Parties included in Annex I to the Convention” . In addition, the EU provided additional information relating to its quantified economy-wide emission reduction target in a submission as part of the process of clarifying the developed country Parties' targets in 2012 .

The EU clarified that the accounting rules for the target under the UNFCCC are more ambitious than the current rules under the KP, for example, including international aviation, adding an annual compliance cycle for emissions under the Effort Sharing Decision (ESD) or higher Clean Development Mechanism (CDM) quality standards under the EU Emissions Trading System (EU ETS) . Accordingly, the following assumptions and conditions apply to the EU's 20% target under the UNFCCC:

- The EU pledge under the UNFCCC does not include emissions/removals from LULUCF, but it is estimated to be a net sink over the relevant period. EU inventories also include information on emissions and removals from LULUCF in accordance with relevant reporting commitments under the UNFCCC. Accounting for LULUCF activities only takes place under the KP.
- The target refers to 1990 as a single base year for all gases and all MS.
- Emissions from international aviation to the extent it is included in the EU ETS are included in the target.
- A limited number of Certified Emission Reductions (CERs), Emission Reduction Units (ERU and units from new market-based mechanisms may be used to achieve the target: In the ETS, the use of international credits is capped (up to 50% of the reduction required from EU ETS sectors by 2020). Quality standards also apply to the use of international credits in the EU ETS, including a ban on credits from LULUCF projects and certain industrial gas projects. In the Effort Sharing Decision (ESD) sectors, the annual use of international credits is limited to up to 3% of each MS's ESD emissions in 2005, with a limited number of MS being permitted to use an additional 1% from projects in Least Developed Countries (LDCs) or Small Island Developing States (SIDS), subject to conditions.
- The GWPs used to aggregate GHG emissions up to 2020 under the EU legislation were those based on the Second Assessment Report of the IPCC when the target was submitted. In its submission to clarify the 2020 target from March 2012, the EU announced that the implications of the Conference of the Parties Serving as the Meeting of the Parties to the Kyoto Protocol’s (CMP) Decision to revise the GWPs to those from the IPCC Fourth Assessment Report (AR4) are under review. This review has been completed and revised GWPs from AR4 were adopted for the EU ETS. For the revision

of ESD targets, the revised GWPs were taken into account. For the implementation until 2020, GWPs from AR4 will be used consistently with the UNFCCC reporting guidelines for GHG inventories.

- The target covers the gases CO_2, CH_4, N_2O, HFCs, PFCs and SF_6.

The key facts about the UNFCCC target of the EU-28 (EU-27 + UK) are summarized in Table 3.1.

Table 3.1 Key facts of the UNFCCC target of the EU-28 (EU-27 + UK)

Parameters	**Target**
Base Year	1990
Target Year	2020
Emission Reduction target	-20% in 2020 compared to 1990
Gases covered	CO_2, CH_4, N_2O, HFCs, PFCs, SF_6
Global Warming Potential	AR4
Sectors Covered	All IPCC sources and sectors, as measured by the full annual inventory and international aviation to the extent included in the EU ETS.
Land Use, Land-Use Change, and Forests (LULUCF)	Not included in the target under Convention. Accounted under KP, reported in EU inventories under the Convention. Assumed to produce net removals.
Use of international credits (JI and CDM)	Possible subject to quantitative and qualitative limits

Source: European Commission

With the 2020 climate and energy package, the EU has set internal rules which underpin the implementation of the target under the UNFCCC. The 2020 climate and energy package introduced a clear approach to achieving the 20% reduction of total GHG emissions from 1990 levels, which is equivalent to a 14% reduction compared to 2005 levels. This 14% reduction objective is divided between two sub-targets, equivalent to a split of the reduction effort between ETS and non-ETS sectors of two thirds vs. one third.

These two sub-targets are:

- A 21% reduction target compared to 2005 for emissions covered by the ETS (including domestic and international aviation);
- A 10% reduction target compared to 2005 for ESD sectors, shared between the 28 MS through individual national GHG targets.

Under the revised EU ETS Directive , one single EU ETS cap covers the EU Member States and the three participating non-EU Member States (Norway, Iceland and Liechtenstein), i.e. there are no further differentiated caps by country. For allowances allocated to the EU ETS sectors, annual caps have been set for the period from 2013 to 2020; these decrease by 1.74% annually, starting from the average level of allowances issued by MS for the second trading period (2008-2012). The annual caps imply interim targets for emission reductions in sectors covered by the EU ETS for each year until 2020. For further information on the EU ETS and for information on the use of flexible mechanisms in the EU ETS see 5th Biennial Report of the European Union (EU-BR5).

Non-ETS emissions are addressed under the Effort Sharing Decision already mentioned above. The ESD covers emissions from all sources outside the EU ETS, except for emissions from international maritime, domestic and international aviation (which were included in the EU ETS from 1 January 2012) and emissions and removals from LULUCF. It thus includes a diverse range of small-scale emitters in a wide range of sectors: Transport (cars, trucks), buildings (in particular heating), services, small industrial installations, fugitive emissions from the energy sector, emissions of fluorinated gases from appliances and other sources, agriculture, and waste. Such sources currently account for about 60% of total GHG emissions in the EU.

While the EU ETS target is to be achieved by the EU as a whole, the ESD target was divided into national targets to be achieved individually by each MS. In the ESD, national emission targets for 2020 are set expressed as percentage changes from 2005 levels. The Czech Republic is allowed to increase its emissions in the ESD sectors by 9% against 2005. These changes have been transferred into binding quantified annual reduction targets for the period from 2013 to 2020, expressed in Annual Emission Allocations (AEAs). The final adjustment of the allocation was carried out in line with the Commission Decision (EU) 2017/1471 of 10 August 2017 amending Decision 2013/162/EU to revise Member States' annual emission allocations for the period from 2017 to 2020.

The quantified annual reduction targets 2013-2020 of the Czech Republic start from 62.5 million AEAs in 2013 and increase to 67.2 million AEAs in 2020.

The monitoring process was harmonized for all European MS and laid down in the Monitoring Mechanism Regulation, succeeded by the Governance Regulation. The use of flexible mechanisms is possible under the EU ETS and the ESD. For the use of CER and ERU under the ETS, please refer to the EU-BR5.

The ESD allows MS to make use of flexibility provisions for meeting their annual targets, with certain limitations. There is an annual limit of 3% for the use of project-based credits for each MS. If these are not used in any specific year, the unused part for that year can be transferred to other MS or be banked for own use until 2020.

For more detailed explanation on how the EU climate and energy package, as well as the EU target under the Convention and the KP are set up and related, please also refer to the EU-BR5.

A further target has been pledged to the Convention through the EU's Nationally Determined Contribution submitted under the Paris Agreement, and has been adopted by the EU under the 2030 Climate and Energy Framework. The emission reduction target is a pledge to reduce emissions by at least 40% (compared to 1990 levels) by 2030, enabling the EU to move towards a low-carbon economy and implement its commitments under the Paris Agreement. In order to achieve this target:

- EU emissions trading system (ETS) sectors will have to cut emissions by 43% (compared to 2005) by 2030. This has been agreed under the Revised EU ETS Directive (2018/410) .

- Effort Sharing sectors will need to cut emissions by 30% (compared to 2005) by 2030 – this has been translated into individual binding targets for Member States. The target for the Czech Republic is 14% emissions reduction against 2005. This has been agreed under the Effort Sharing Regulation (2018/842) . While the Effort Sharing Regulation does not cover the LULUCF sector as such, it does allows Member States to use up to 280 million credits from the land-use sector over the entire period 2021-2030 to comply with their national targets.

- Emissions and removals from the LULUCF sector are included for the first time in the EU climate target through the so-called LULUCF Regulation (2018/841) . Each Member State will have to ensure that the LULUCF sector does not create debits, once specific accounting rules are applied. This is known as the "no debit" rule.

An update of the the EU's Nationally Determined Contribution was submitted in December 2020 increasing the overall emission reduction target to at least 55% compared to 1990 levels by 2030. All the above mentioned subtargets and Member States targets will be increased accordingly based on the currently still debated "Fit for 55" legislative package.

For Tabular summary of the information provided in this Chapter please see CTF Tables 2 and 3.

4. Progress in achievement of quantified economy-wide emission reduction targets and relevant information

4.1 Assessment of progress in achievement of quantified economy-wide emission reduction target

Under the UNFCCC, the EU and its Member States committed to achieving a joint quantified economy-wide greenhouse gas emission reduction target of 20 percent below the 1990 level by 2020. It is a joint pledge with no separate targets for Member States under the Convention. The UK remains part of the joint EU 2020 target together with the 27 EU Member States. The LULUCF sector is excluded from the target under the Convention, while emissions from outgoing international flights are included (covered by EU-ETS).

The EU has jointly fulfilled its UNFCCC target and implemented it internally through EU legislation in the 2020 EU Climate and Energy Package that was adopted in 2009. In the package, the EU introduced a clear approach to achieving the 20% reduction in total GHG emissions from 1990 levels, by dividing the effort between the sectors covered by the EU Emissions Trading System (EU ETS) and the sectors under the Effort Sharing Decision (ESD), where national targets for Member States apply. The achievement of EU internal compliance under the 2020 Climate and Energy Package is not subject to the UNFCCC assessment of the EU's joint commitment under the Convention. The EU has substantially overachieved its reduction target under the Convention, which means that also its Member States and the UK have fulfilled their emission reduction obligations.

Greenhouse gas emissions within the scope of the target under the Convention amounted to around 3771 Mt CO_2 eq in 2020 which is around 34.0 below the 1990 level of 5710 Mt CO_2 eq The emissions of the United Kingdom are included here because it was part of the EU at the time of target setting, and EU legislation applied in the United Kingdom until 31 December 2020. Hence, the EU target under the Convention for 2020 has been overachieved by the EU, its Member States and the United Kingdom.

4.2 Targets of the Czech Republic

The quantified annual reduction targets 2013-2020 of the Czech Republic under the Effort Sharing Decision start from 62.5 million AEAs in 2013 and increase to 67.2 million AEAs in 2020. The Czech Republic has fullfiled its obligations for each year of the period (the compliance cycle for 2020 is still ongoing) and transferred part of its surplus to Germany in 2022.

Table 4.1: Annual Emission Allocation of the Czech Republic compared to the ESD emissions

Year	ESD AEA allocation	ESD emissions [t CO_2 eq]
2013	62 474 354	61 457 570
2014	63 214 367	57 620 658
2015	63 954 381	61 282 020
2016	64 694 394	62 816 957
2017	65 212 313	62 395 184
2018	65 876 424	60 616 480
2019	66 540 535	60 543 276
2020	67 204 645	58 650 330
Total	519 171 413	485 382 475

The EU ETS target is to be achieved by the EU as a whole. In 2020, verified emissions of stationary installations covered under the EU ETS in the Czech Republic summed up to 54.68 Mt CO_2 eq. With the total GHG emissions of 113.34 Mt CO_2 eq. (excluding LULUCF), the share of ETS emissions was 48%. For more information about EU ETS emissions please refer to Table 4.1 of the 8th National Communication of the Czech Republic.

Besides achieving the targets coming from the EU legislation, the Czech Republic has also achieved its domestic target to reduce GHG emissions by 2020 by 20% against the 2005 level as set by the Climate Protection Policy of the Czech Republic. The total GHG emissions excluding LULUCF in 2020 decreased by 24% against 2005 and by 43% against 1990.

4.3 Policies and Measures and Other Information

Relevant information on policies and measures is reported in Chapter 4 of the 8th National Communication of the Czech Republic. Information on mitigation actions and their effects is included in the CTF Table 3, while additional information is provided in other CTF tables.
The progress in achieving the quantified target is reported in CTF Table 4. Emissions in the LULUCF sector are not included under the UNFCCC target, therefore they are not included in CTF Tables 4 and 4(a).

For information on the Minimization of Adverse Impact see Chapter 15 of the National Inventory Report submitted in April 2022 to the UNFCCC. More information on the EU-wide assessment procedures is available in section 4.4 of the 5th Biennial Report of the European Union.

There were no significant changes in domestic institutional arrangements, including legal, administrative and procedural arrangements since the last Biennial Report.

5. Projections

The projections of GHG emissions and removals and all relevant information are included in Chapter 5 of the 8th National Communication of the Czech Republic and the CTF Tables 5 and 6.

6. Provisions of financial, technological and capacity-building support to developing country Parties

Information about provision of financial support to developing country Parties is Chapter 7 of the 8th National Communication of the Czech Republic and CTF Table 7. The relevant projects with strong capacity bulding component are included also in CTF Table 9. The CTF Table 8 was intentionally left blank.

7. Other reporting matters

According to paragraph 24 of the BR guidelines, Annex I Parties are encouraged to report, to the extent possible, on the domestic arrangements established for the process of the self-assessment of compliance with emission reductions in comparison with emission reduction commitments or the level of emission reduction that is required by science and on the progress made in the establishment of national rules for taking local action against domestic non-compliance with emission reduction targets.

The Czech Republic has in place a national system for reporting on policies and measures and projections of emissions and sinks and is planning to further enhance the system in line with the EU Governance Regulation which also requires the Member States to report on their progress and compliance with targets. Part of the arrangement is also the Inter-ministerial working group on climate change issues. Among its tasks is also to assess the progress made and share the information with different stakeholders. The Czech Republic has also established a process of evaluation and update of the Climate Protection Policy of the Czech Republic which serves as a long-term strategy in line with the Paris Agreement.

On the EU level the European Climate Law has established a the The European Scientific Advisory Board on Climate Change with the following tasks:

(a) considering the latest scientific findings of the IPCC reports and scientific climate data, in particular with regard to information relevant to the Union;

(b) providing scientific advice and issuing reports on existing and proposed Union measures, climate targets and indicative greenhouse gas budgets, and their coherence with the objectives of this Regulation and the Union's international commitments under the Paris Agreement;

(c) contributing to the exchange of independent scientific knowledge in the field of modelling, monitoring, promising research and innovation which contribute to reducing emissions or increasing removals;

(d) identifying actions and opportunities needed to successfully achieve the Union climate targets.

The national rules for taking action against possible non-compliance of entities included in the EU ETS were established by the Act No. 383/2012 Coll. on conditions for trading of emission allowances. For the Effort Sharing sectors there are no specific national rules since the Effort Sharing is directly applicable. Non-compliance on national level could result in infringement procedure and possible penalty payment.

ANNEX 2 Summary of supplementary information pursuant to Article 7.2 of the Kyoto Protocol

Following table gives a summary of supplementary information pursuant to Art. 7.2 of the Kyoto Protocol in classification according to the 8th National Communication.

Summary of supplementary information pursuant to Article 7.2 of the Kyoto Protocol

Information pursuant to Art. 7.2		**Relevant part of the 8th National Communication**
National system of inventories of greenhouse gases pursuant to Art. 5.1		Chapter 3.3
National registry of trading in allowances		Chapter 3.3.11
Mechanisms pursuant to Art. 6, 12 and 17		Chapter 4.4
Policies and measures pursuant to Art. 2		Chapter 4.2, 4.3
Domestic and regional programs, legislative instruments, effectiveness and administrative procedures		Chapter 4.1
Information pursuant to Art. 10	Art. 10a	Chapter 3.3
	Art. 10b	Chapter 4.1, 4.2, 4.3 and 4.4
	Art. 10c	Chapter 7.3
	Art. 10d	Chapter 8
	Art. 10e	Chapter 9
Funding		Chapter 7

ANNEX 3 Summary of all quantifiable implemented and planned measures

Title of measure	Expected benefit in reducing greenhouse gas emissions (kt CO_2 eq./year)		Status of implementation
	2020	2030	
EU ETS	2,740.00	6,624.00	Implemented
Air protection act (201/2012 Coll) - framework legislation	IE	IE	Implemented
The Climate Protection Policy of the Czech Republic	IE	IE	Implemented
National Energy Efficiency Action Plan	IE	IE	Implemented
National Strategy of Cycling Transport Development	100.00	89.00	Implemented
Operational Programme Transport	150.00	390.00	Implemented
Support of biofuels	176.00	152.00	Implemented
Regulation on CO2 from passenger cars	237.00	803.00	Implemented
EU regulation on CO2 from light-commercial vehicles (vans)	486.00	787.00	Implemented
Support of public transport and modal shift from road transport	134.00	109.00	Implemented
ICAO agreement	6.00	17.00	Implemented
Energy act	IE	IE	Implemented
Operational Programme Environment 2007 - 2013	232.00	185.00	Implemented
Operational Programme Environment 2014 - 2020	372.00	426.00	Implemented
Directive 2009/125/ES on eco-design	438.00	466.00	Implemented
Implementation of the Directive on the energy performance of buildings (2010/31/EU)	532.00	446.00	Implemented
National Renewable Energy Action Plan	IE	IE	Implemented
Operational Programme Enterprise and Innovation	204.00	181.00	Implemented
Operational Programme Enterprise and Innovation for Competitiveness	899.00	1,381.00	Implemented
New Green savings programme 2013 - 2020	530.00	435.00	Implemented
Integrated Regional Operating Programme	164.00	241.00	Implemented
Act No. 406/2000 Coll., on energy management	IE	IE	Implemented
State programme on the promotion of energy savings (EFEKT 2)	57.10	50.50	Implemented
ENERG Programme	4.00	3.00	Implemented
Operational Programme Prague Growth Pole	4.00	4.00	Implemented
Program PANEL/NEW PANEL/PANEL 2013 +	17.00	16.00	Implemented
Implementation of Directive 2012/27/EU on energy efficiency (Article 5)	IE	IE	Implemented
Preferential feed-in tariffs for electricity produced from renewable energy sources	3,242.00	4,047.00	Implemented
JESSICA Programme	2.00	2.00	Implemented
Implementation of Regulation (EU) No 517/2014 of 16 April 2014 on fluorinated greenhouse gases and repealing Regulation (EC) No 842/2006	552.00	2,029.00	Implemented
Implementation of Kigali Amendment to Montreal Protocol	IE	IE	Implemented
Emission limits in Air protection act (201/2012 Coll.)	2,600.00	2,746.00	Implemented
Cross Compliance - fulfilment of Good Agricultural and Environmental Conditions	IE	IE	Implemented
Nitrate Directive (1991/676/EEC) - 4th Action Plan	IE	IE	Implemented
Strategy for Growth in Agriculture	250.00	300.00	Implemented
Action Plan for biomass in the Czech Republic	125.00	255.00	Implemented
Rural Development Programme 2014 - 2020	200.00	357.00	Implemented
Action Plan for Development of Organic Farming 2016-2020	IE	IE	Implemented
Ministry of Agriculture Strategy with view until 2030 (since 2016)	IE	IE	Implemented
Updated recommendations for implementing the proposed measures of NLP (National Forest Plan) II	458.00	395.00	Implemented
Waste management plan 2003 and 2011	524.00	974.00	Implemented
Waste management plan 2015 - 2024	330.00	330.00	Implemented
Circular Economy Package (CEP)	IE	IE	Implemented

Title of measure	Expected benefit in reducing greenhouse gas emissions (kt CO_2 eq./year)		Status of implementation
	2020	2030	
Modernisation Fund	0.00	17,500.00	Planned
Energy efficiency measures in industry sector in the period 2021 - 2030	0.00	1,809.00	Planned
Soft energy efficiency measures in the period 2021 - 2030	0.00	973.00	Planned
Energy efficiency measures in residential sector in the period 2021 - 2030	0.00	1,110.00	Planned
Energy efficiency measures in commercial and institutional sector in the period 2021 - 2030	0.00	559.00	Planned
Economic and tax tools for road vehicles	0.00	39.00	Planned
Road toll	126.00	103.00	Planned

Source: CHMI

ANNEX 4 Information on selected important national research projects

Please note that below mentioned projects serve only as an example of all projects on climate change which were financed in the Czech Republic from 2017 to 2021. The extensive list of projects which were financed in that period can be found on the TA ČR Starfos web page[49] which presents data on research, development, and innovation conducted with the support from the government budget.

- **Prediction, Evaluation and Research for Understanding National sensitivity and impacts of drought and climate change for Czechia** (project, provider TA CZ, chief beneficiary Czech

TA CZ project SS02030040, main beneficiary **Czech Hydrometeorological Institute**, period of implementation: 2020–2026

The aim of the project is to create a research centre that will focus on research in the field of climate change in a long-term perspective. It concerns an analysis of the ongoing and prediction of future change, including identification of risks for the environment and society. The output will be the most up-to-date data necessary for the preparation and updating of strategic documents as well as for decision-making processes not only within area of climate change adaptation, but also for evaluation of mitigation measures in the process of their preparation and implementation. The output of the particular objectives described in the project will be a publicly accessible comprehensive research report supplemented by open databases, certified methodologies and, of course, scientific publications.

- **Water systems and water management in the Czech Republic in conditions of climate change**

TA CZ project project SS02030027, main beneficiary **The T. G. Masaryk Water Research Institute**, period of implementation: 2020–2026

The aim of the project is, through the activities of the Water Research Centre, to support better knowledge in the areas of: - future water requirements in terms of (a) climate change and (b) induced changes in society, - comparison of future water requirements with the amount of available water and identification of water deficit areas, - the impact of climate change on ecosystems and continued anthropogenic effects on aquatic environments, - inputs, quantities, paths and the effects of pollution in current indicators causing of not reaching of good water status, - reducing the amount and level of pollution in industrial wastewater. With the help of new findings and through their dissemination, it will be possible to support of the considerable resilience of the society in the following ways:

- preparation of adaptation and mitigation measures, assessing their effectiveness individually, within their systems,
- optimizing their design in terms of both: effectiveness and economic efficiency,
- improving, or at least holding, the good environmental status in climate change conditions.

The project will ensure long-term research projects that require the necessary time and capacities. The project is focused especially on the Specific Objective 1 of the Program, especially on the issue of water management, drought, mitigation of its impacts on human settlements and nature. The project aims to become an important contribution to the creation of the “climate package of the Czech Republic”. However, it also deals with the issue of floods, specifically in climate change conditions. The aim of the project is also to contribute to the fulfillment and updating of strategic concepts at the level of the

[49] https://starfos.tacr.cz/en

state and regions, in particular the Strategy of Adaptation to Climate Change, Concept of Drought Protection, River Basin Management Plans and Flood Risk Management Plans. The project results will also have a legislative impact.

- **SustES - Adaptation strategies for sustainable ecosystem services and food security under adverse environmental conditions**

The Ministry of Education, Youth and Sports project EF16_019/0000797, beneficiary **Global Change Research Institute of the Czech Academy of Sciences**, period of implementation: 2018–2022

The project aims to develop a fundamentally new concept for identification of risks and adaptation strategies to ensure the sustainability of ecosystem services (ie. the services provided to human by landscape), and particularly the food safety (ie. ensuring sufficient amount of food of adequate quality) in terms of ongoing climate and socio-economic changes. This concept will be through the newly developed tools able to exactly analyze the impacts of climate change on all key ecosystem services in landscape. Subsequently, the new adaptation measures leading to increased retention of water in the landscape, improved nutrient cycling, reduced greenhouse gas emissions, reduced erosion risks and pollution or eutrophication of surface- and ground-water will be designed and tested. Such adaptation measures will then lead to improvement of production and non-production functions of landscape. Utilization of cost-benefit analysis will enable the optimization of adaptation measures that are economically efficient and sustainable in future climatic conditions. All activities will be linked to the development of holistically conceived adaptation strategies combining global and local factors in an original and innovative way. Thanks to the cooperation of experts from the fields of climatology, mathematical modeling, paleoclimatology, atmospheric physics, geoinformatics, system ecology, ecophysiology, agronomy, forestry, metabolomics, food chemistry, bio-energy, and also economics and environmental economics, the project will enable the creation of a research program based on interdisciplinary and international team that will rely on the unique infrastructure of the Global Change Research Institute CAS. During project realisation will be created, in a very short time, multidisciplinary, international and highly skilled team of experts, which will compete with European best research centers with their abilities, output complexity and quality results.

- **CzechGlobe 2020 – Development of the Centre of Global Climate Change Impacts Studies**

The Ministry of Education, Youth and Sports project LO1415, beneficiary **Global Change Research Institute of the Czech Academy of Sciences**, period of implementation: 2015–2019

The subject matter of the project was financing of science and development for ensuring effective sustainability and development of CzechGlobe – Centre for Global Climate Change Impacts Studies, which was formed within the scope of the Operational Programme Research and Development for Innovation in 2010-2014. The main goal of the project was scientific and research activity and continuous development of the research infrastructure of CzechGlobe for the purpose of enforcement of competitiveness of the Czech research of the global change impacts in these areas:

o Support and implementation of the research in the area of the global climate change impacts, ecosystems and human society, development of the corresponding adaptation and innovation procedures.

o Development of the research infrastructure of CzechGlobe in connection with the global change research requirements, creation of conditions for the human resources development with emphasis on strengthening of upbringing, education and mobility of students and researchers.

o Intensification of the long-term international cooperation, mainly through active participation in the European Strategy Forum on Research Infrastructures (ESFRI) and other international projects.

o Intensive cooperation with the public and private sector with the aim to implement the results created in CzechGlobe, and thus to strengthen the social and economic development of the Czech Republic

- **Drought Stories: Local Contexts of Extreme Climate Events, their Perception and Willingness of Actors to Public Participation**

TA CZ project TL02000048, beneficiary **Charles University**, period of implementation: 2019–2022

The main goal of the project is to increase the involvement of ordinary citizens, stakeholders and public administration in creating drought protection measures and to motivate them to sustainable water management. Partial objectives: (1) To identify dominant narratives of drought in expert, political, media and local discourses; (2) To identify ways of enhancing civic participation, dialogue between laics and experts, including citizen science, in the area of water management (3) To develop a multimedia application visualizing landscape changes in relation to water scarcity, including maps and predictions, modelling the natural and social impacts of long-term drought, and to assess application's applicability in education, policy making and communication with the public.

- **Research of key soil-water ecosystem interactions at the SoWa Research Infrastructure**

The Ministry of Education, Youth and Sports project EF16_013/0001782, beneficiary **Biology Centre of the Czech Academy of Sciences**, period of implementation: 2017–2020

The main objective of the project is the detailed study of biotic and abiotic processes and interactions between soil and aquatic ecosystems in micro-, meso- and macroscale within six research programs. All research programs are closely interconnected and linked to the VI SoWa research section (www.soilwater.cz). Together they improve our understanding and knowledge of complex biotic and abiotic interactions that influence the flow of nutrients inside and between soil and aquatic ecosystems. The main goal of the project is the improvement of facilities, modernization and development VI SoWa a number of unique, unique and highly sophisticated equipment. Within the project, a unique experimental basin and a set of experimental mesocosms will be used, and VI SoWa will be newly equipped with a number of sensitive instruments that will significantly increase the sensitivity, selectivity, quality and quantity of analyzes. This will increase the prestige and attractiveness of VI SoWa for cooperation with major foreign research institutions and universities and the involvement of VI SoWa in international research projects.

- **Effect of global changes on fungal biogeography and ecosystem functioning**

Grant Agency of the Czech Republic project GM21-20802M, beneficiary **Institute of Microbiology of the Czech Academy of Sciences**, period of implementation: 2021–2025

Fungi are eukaryotic microorganisms that play fundamental roles in regulating key ecosystem processes. As major decomposers of organic matter as well as mutualists or pathogens of plants, soil fungi significantly influence plant primary production, carbon sequestration, and act as crucial regulators of the soil carbon balance, which is one of the greatest topics of human security. Although the wealth of our civilization profoundly depends on globalization and free market, there is also another side to this coin, represented by the global changes of environment and easier spread of pathogens of humans, animals and plants. Climate change and world biota globalization constitute most important challenges which affect the functioning of natural as well as agricultural ecosystems. Understanding the consequences of inevitable global changes on biota and ecosystem functioning have to be primary interest of current biological research.

- **Response of microbial communities to changing climate in Arctic tundra soils**

Grant Agency of the Czech Republic project GM21-19209M, beneficiary **Institute of Microbiology of the Czech Academy of Sciences**, period of implementation: 2021–2025

Climate models predict substantial changes in temperature and precipitation patterns across the Arctic regions in future decades. Microbes are known to play key roles in determining the stability of soil carbon (C) and its possible release into the atmosphere as carbon dioxide and methane. Carbon-rich Arctic soil ecosystems are particularly vulnerable to C losses due to warming and subsequent ecosystem disturbances as wildfires. On the other hand, the release of C from soil to the atmosphere could be mitigated due to increased plant growth or reduced due to drought. Here we propose to characterize the response of soil microbes to the conditions caused by future climate change (increased winter precipitation, summer warming and wildfires); and to identify microbial processes affecting shrub expansion in Greenland. By combining soil, plant and microbial C pools and fluxes at the sites, the study will help in understanding whether Arctic soils will become C sink or source under future climate change.

- **Management of forest genetic resources under climate change**

TA CZ project TO01000243, beneficiary **Czech University of Life Sciences in Prague**, period of implementation: 2021–2024

In the framework of the in-situ forest tree gene-resource management, the project is focused on addressing the following key objectives. Each objective will be fulfilled by novel methodological development and software solutions validated in the operational tree improvement programs in Norway and the Czech Republic. 1. development and validation of a novel genetic evaluation protocol, 2. economic evaluation utilizing improved selection indices, 3. adoption of spatial seed orchard layouts to accommodate specific constraints in advanced generations, 4. development of genetic thinning algorithm promoting random mating and minimizing inbreeding in seed orchards, 5. utilizing stochastic simulation: comparison of the efficiency of alternative tree improvement strategies.

- **Optimization of silviculture procedures for adaptation of forest ecosystems to climate change**

The Ministry of Agriculture project QK21020307, main beneficiary **Forestry and Game Management Research Institut**e. Project has been implemented from 2021 to 2023.

The aim of the project is to modify silviculture practice in forest ecosystems in order to increase their resistance to stress caused by various climatic extremes in connection with climate change. The main predicted factors will be drought and high air temperatures within the growing season. The new "adaptive silviculture practices" will be designed to be used to update the state forestry policy. Proposals for modifications of cultivation methods will be divided into 4 areas: 1. modification of species composition, 2. optimization of forest density, 3. increase of age and spatial diversity, 4. specific procedures for the restoration of calamity clear-cuts.

- **CzechGlobe - Environmental justice analysis to advance rural landscape transformations in the face of climate change**

The Ministry of Education, Youth and Sports supported project 8F20015 and the chief beneficiary was the **CzechGlobe – Global Change Research Institute of the Czech Academy of Sciences (GCRI)**. Project has been implemented from 2020 to 2023.

The Just-Scapes project will explore the meaning and practice of “just transformation” in the face of climate change. The project defines this as widescale and deep-rooted social-ecological change that combines environmental goals (including decarbonisation and protection of biodiversity) with social justice goals. Justice goals relate not only to the distribution of the effects of climate change but also to the effects of climate policy responses. This attention to social justice involves challenging inequalities across categories such as race, gender, wealth, belief system and generations, and adhering to the UN's 2030 Agenda to 'leave no one behind'. The idea of 'just transformation' views social justice as a goal in its own right, but also as instrumental to overcoming 'justice barriers' to the visioning and implementation of transformational change. Such barriers are increasingly evident across Europe, with some climate policies viewed as socially regressive, disproportionately impacting on low income and rural households (for example the Gilets Jaunes movement in France).

- **Role of root-associated fungi in plant response to climatic change**

The Ministry of Education, Youth and Sports supported project LTAUSA17166 and the chief beneficiary was the **Institute of Botany of the Czech Academy of Sciences**. Project ran from 2017 to 2019.

To describe communities of root-associated fungi of two plant species in a field experiment in Northern Arizona, which addresses the role of co-adaptation of plants and their root-associated fungi in plant adaptation to climatic change.

The project collected samples of roots and rhizosphere soils; from three experiments of the US partner. The first and largest experiment has rendered data on plant growth, fungal root colonization and the composition of the root-associated fungal communities. First data analyses link the development of the fungal communities with plant growth as depending on the soil and climatic conditions.

- **The effect of changed environmental conditions on South Moravian floodplain forest ecosystems**

The Ministry of Education, Youth and Sports supported project LTC19013 and the chief beneficiary was the **Mendel University in Brno**. Project ran from 2019 to 2021.

The goals of this project are: 1) to describe how the Quercus robur and Fraxinus angustifolia have responded in their radial growth to past rivers regulation and associated groundwater level changes; 2) to describe how the Quercus robur and Fraxinus angustifolia have responded in their radial growth to increasing temperature and changing precipitation pattern linked with ongoing climate change; 3) to found whether Quercus robur and Fraxinus angustifolia is now facing drought stress; to found the time changes of understory herb layer composition in relation to rivers regulation and climate change.

- **Mobility CzechGlobe 2**

The Ministry of Education, Youth and Sports supported project EF18_053/0016924 and the chief beneficiary was the **CzechGlobe – Global Change Research Institute of the Czech Academy of Sciences (GCRI)**. Project has been implemented from 2020 to 2022.

Development of a research institution through the strengthening of human resources, especially in the field of studying the impacts of climate change on the water regime and drought risks on a planetary and local scale, as well as improving the methods of measured data. Within the planned mobilities, the following will take place: 1) the arrival of three foreign senior researchers, who mainly deal with the study of the impacts of climate change on the water regime and the risk of drought on a local and global scale or e.g. the study of the impact of climate on ecosystems 2) the departure of two junior researchers, whose trip will contribute to the improvement of methods of measured climate data and a new methodology for the separation of gross primary production and ecosystem respiration, as well as to achieve higher accuracy, integration of external data inputs and validation of proposed methodologies. The results of the internship will not only improve the quality of eddy-covariation data processing, but also significantly simplify the entire process chain.

This project follows the project CzechGlobe 2020 – Development of the Centre of Global Climate Change Impacts Studies which was realised from 2015 to 2019.

- **Dynamical and statistical climate modelling for the activities within the CORDEX programme**

The Ministry of Education, Youth and Sports supported project LTT17007 and the chief beneficiary was the **Charles University, Faculty of Science**. Project ran from 2017 to 2021.

The main objective of the project is to support the participation of climatologists from the Czech Republic in the selected flagship pilot studies (FPS) of the CORDEX activity. This objective will be materialized through four major goals, corresponding to the involvement of the team groups in the FPSs: 1. Implementation of a non-hydrostatic model in the selected domain and experimental simulations as a part of a multi-model ensemble, evaluation of benefits of the non-hydrostatic approach and its influence in a changing climate, in particular for extreme precipitation, and of systematic differences in cloud cover and temperature 2. The development of "convection emulators", i.e., statistical tools to simulate (and potentially bypass) dynamical (regional climate) convection-permitting models in a very high resolution 3. The development of statistical downscaling methods, esp. for precipitation, and their implementation in southeastern South America; comparison of results of statistical and dynamical downscaling 4. Experimental simulation for a sensitivity analysis of climatic effects of land-use, validation of simulations for a variable land-use, and potential impacts of future land-use changes for climate change projections.

- **Policy responses and governance of adapting agriculture systems in dry regions to climate change (comparative study- Czech Republic and the Republic of Sudan)**

The Ministry of Education, Youth and Sports supported project LTC18072 and the chief beneficiary was the **CzechGlobe – Global Change Research Institute of the Czech Academy of Sciences (GCRI)**. Project ran from 2018 to 2021.

This proposed project comes as a part of the activities of COST Action CA16233. It aims to conduct a comparative study analysis of policy responses and institutional arrangements which are tackling the adaptation of the agricultural system in both Czech Republic and in Sudan to climate change. A main part of the project is to identify hinders and gaps in policy and governance that potentially undermine crop and animal husbandry productive capacities in dry regions under the forecasted climate change stresses; and thereafter, to develop an assessment tool for best policy and institutional practices in both regions. It seeks to formulate concepts by focusing on similarities and contrasts among the two different cases which have different degrees of aridity and technological scale.

- **From Graphene Hybrid Nanostructures to Green Electronics**

The Ministry of Education, Youth and Sports supported the project LL1301 and the chief beneficiary was the **J. Heyrovský Institute of Physical Chemistry of the Czech Academy of Sciences**. The project ran from 2013 to 2018.

The aim of the project is to study new principles for the breakthrough development of low energy consumption electronic devices. The ultimate challenge of the project is to build up a bilayer pseudospin field-effect transistor (BISFET). The BISFET is an example of new 'green' transistor architecture which relies on the unique properties of carbon nanostructures. The proposed approach is based on employing graphene multilayers and graphene sandwiches. The latter structure represents new class of graphene hybrid nanomaterials. To form graphene sandwiches the monolayer of the active material were inserted in between two layers of graphene. Different classes of materials were encapsulated including: dielectrics, fullerenes, nanoparticles, polymers and biomolecules. The interaction between graphene shell and encapsulated species were studied. Graphene sandwiches appear to be extremely suitable systems for studies of charge transfer through graphene sheets. It was planned to employ in situ spectroscopies during the electrochemical charging and/or chemical doping. Expected clarification of the mechanism of the charge transfer from graphene to encapsulated species also allows the tuning of the charge state of the encapsulated species.

- **Netme Centre Plus**

The Ministry of Education, Youth and Sports supported the project LO1202, the main beneficiary of which was **Brno University of Technology.** The project ran from 2014 to 2018.

The main objective of the project was basic and partly also applied research in the field of progressive engineering technologies with a focus on power engineering, process engineering, environmental technologies, mechatronics, virtual design and testing, aerospace and automotive technology and progressive metal materials. In terms of content and expertise, the Centre was focused on progressive technologies of mechanical engineering with border overlaps into related and increasingly important fields. It focused on the field of mechanical engineering and within it on the areas of process engineering, environmental technologies, mechatronic systems, advanced materials, virtual design and testing, engineering, forming and construction methods, automotive and aerospace technologies.

- **Theoretical aspects of energy treatment of waste and protection of the environment from negative impacts**

The Ministry of Education, Youth and Sports supported the project LO1208, the main beneficiary of which was **VŠB – Technical University of Ostrava.** The project ran from 2014 to 2018.

The main objective of the project was to use the infrastructure built within the previous project solution "Institute of Environmental Technologies", i.e. a research pavilion built, pilot plant, research and analytical laboratories and research teams that: (a) explore and optimise effective methods and technologies in the field of energy recovery of waste; b) use the established Centre (and its infrastructure) for the professional public (including lifelong learning programmes with a practical part); c) use the Centre for study stays and work of Master's and Doctoral students, including their provision; d) use the Centre for Work Placements of Workers from Practice; e) use the professional background for communication with the public to increase awareness of current environmental and health problems – in a different way than differently targeted information interpreted only through the media.

- **Energy in conditions of sustainable development**

The Ministry of Education, Youth and Sports supported the project LO1210, the main beneficiary of which was **Brno University of Technology.** The project ran from 2014 to 2018.

The main objectives of the project were: (a) support fundamental research into the generation, conversion, transmission, storage and efficient use of electricity in conditions of sustainable development; (b) enable further career development, in particular of young talented researchers; c) deepen cooperation with the application sphere in the region of competence, intensify involvement in international cooperation; (d) create an environment for the efficient use and operation of research infrastructure. One of the main research objectives of the project was to optimize the conversion and use of energy in systems with ecological energy sources, which will also bring effective energy management. An important aspect of sustainable development is, for example, the issue of ecological transport, another research content of the project. Other research activities of the project included research and development of technologies for further use of renewable energy sources, including research into the use of hydrogen in fuel cells or internal combustion engines.

- **Innovation for Efficiency and the Environment – Growth**

The Ministry of Education, Youth and Sports supported the project LO1403, the main beneficiary of which was **VŠB – Technical University of Ostrava.** The project ran from 2015 to 2019.

The main focus of the Centre was a set of interconnected activities focused on the areas of efficiency solutions, properties and characteristics of low-power power plants, small solid fuel combustion plants with various combustion principles, small ORC units suitable for use with current technologies with less production of low-potential waste heat, research of technologies for the accumulation of low-potential waste heat and subsequent transformation into electrical energy. Emissions of solid particles from energy processes from many research perspectives were also an important area. In the field of gasification, it was the optimization of the process using both traditional biomass and, above all, new types of agrofuels, the research of transitions between the autothermal and alluthermic processes and the related production of liquid fuel Fischer-Tropsch by synthesis. A newly built technology within the INEF project was used for these gasification works. The last major area of the project was the identification and development of methods of solving problems related to the safety of production, storage, transport and use of fuels and the development of methods and development of application approaches in risk governance in the emerging area of safety of purposefully used and inadvertently emerging nanomaterials both in the energy sector and in thermal processes in general.

- **Sustainable development of the ENET Centre**

The Ministry of Education, Youth and Sports supported the project LO1404, the main beneficiary of which was VŠB – Technical University of Ostrava. The project ran from 2015 to 2019.

The main objective of the project was mainly interdisciplinary oriented basic research of theoretical aspects in the field of energy extraction from non-traditional sources and optimal integration into the energy system of the Czech Republic. The project was also based on feedback from users of the results. The research covered the phases of transport technology, treatment and processing of energy feedstocks, fuels and by-products, the phase of effective transformation into media suitable for electricity and thermal energy production, and finally the phase of integration of renewable sources of electricity into the grid, including energy storage, island mode of distributed electricity sources and smart grids components. Attention was also focused on research into factors of efficient management of resources in accordance with trends in sustainable development. An important part of the project was research carried out on the basis of the results of diagnostics of industrial energy equipment, which allows feedback for effective technology management. The built Centre made it possible to involve students of doctoral and master's degree programmes of several faculties in research and to increase the interest of partners in domestic and foreign cooperation.

- **Institute of Clean Technologies of Extraction and Use of Energy Raw Materials – Sustainability Project**

The Ministry of Education, Youth and Sports supported the project LO1406 the main beneficiary of which was **VŠB – Technical University of Ostrava.** The project ran from 2015 to 2019.

The main content of the project was a set of interconnected activities aimed at combining basic research with application solutions in the broad issue of using the earth's crust to ensure the energy requirements of sustainable development of society. The task of the research program 1 "Multiphase rock environment" was to gain knowledge of physical, chemical, isotope, structural and mechanical properties of environmental components using modern instrumental technology, which significantly increases the level of knowledge and the possibilities of their generalization for given geological conditions using mathematical modeling. This information was the basic prerequisite for the design of environmentally friendly technologies in the exploitation of mineral resources and in the further use of the rock environment. Specifically, it was the issue of properties and behavior of geomaterials depending on their internal structure, method of loading and physical conditions, research of geomaterials with application in technologies for construction and the environment and the study of mineral resources for their preparation and identification of the origin of gas in the rock environment and its usability to increase the recoverability of deposits. The main objectives of the research program 2 "Environmentally friendly technologies" were the research of phenomena in dispersion systems and the application of membrane processes in the treatment and purification of water from mining and post-mining activities, the development of changes in induced voltage and deformation fields in the underground use of the rock massif and the safety aspects of environmentally friendly technologies related to the extraction of mineral resources in terms of explosiveness, flammability, self-ignition and dustiness.

- **Tree Dynamics: Understaning of Mechanical Response to Loading**

The Ministry of Education, Youth and Sports supports the project LL1909 and the chief beneficiary is the **Mendel University in Brno**. The project has been running from 2020 to 2024.

Tree biomechanics currently gains attention due to its significance to environmental and social needs. On one side the greenery helps to ensure condition of human healthy life in changing climate, on the other side more abrupt weather changes lead to bigger damages of forests and trees in urban areas and increasing risk of human safety violation and property damages. One of the key parameters in assessment of hazard is mechanical behaviour of a tree. Current methods used for prediction of tree behaviour and safety are based on a number of simplifications, such as trivial geometry, elastic material or the static loading and response. The complex understanding of a tree dynamic mechanical response to loading is required and missing and, therefore, addressing such call is the general objective of this project. Due to the complexity of the living system of a tree, there is a necessity to employ various techniques to develop a theory of its fundamental mechanical behaviour. For this reason, the project intends to couple: 1) laboratory experimental mechanical testing of particular tree tissues on various scales (micro to macro) to capture heterogeneity and variability of the material properties; 2) advanced photogrammetry approaches to obtain complex 3D morphology of a tree; 3) computational modelling to create general and comprehensive physical models of trees for structural static and dynamic analyses, within which both morphological and deterministic approaches will be employed to verify the models against experiments; 4) aerodynamic analyses combining the laboratory testing of tree parts in a wind tunnel including particle image velocimetry and the computational fluid dynamics of tree and tree environment; 5) non-destructive and destructive in situ testing of trees using static pulling, dynamic pull-and-release, impact tests or long-term recording with 3D motion capture analyses based on digital image correlation, acoustic emissions analyses and advanced vibrometry.

- **Microbial Production and Release of Methane (CH_4) from the Greenland Ice Sheet**

The Ministry of Education, Youth and Sports supports the project LL2004 and the chief beneficiary is the **Charles University**. The project has been running from 2020 to 2025.

Recent research has shown the melting Greenland ice sheet is a source of methane, a potent greenhouse gas, and thus identified a potential positive climate feedback1,2. Addressing the rising concerns about the warming Arctic, MARCH4G aims to quantify the potential of the Greenland ice sheet subglacial ecosystem to produce and release CH_4 into the atmosphere and affect the global CH_4 cycle.

ANNEX 5 Examples of EE&A-related projects in the field of climate change implemented by NGOs in 2017–2021

- ***The RAINBOW movement - Friends of the Earth Czech Republic - Decentralized energy sources - possibilities of adaptation to climate change in the urban environment***

The aim of the project Decentralized energy sources - possibilities of adaptation to climate change (not only) in the urban environment was to increase the awareness of selected target groups about the benefits of renewable energy sources and energy self-sufficiency. Printed and online media and social networks were used to mediate the issue. In order to increase the attractiveness of the topic, an all-day information and entertainment event for the public was organized in Prague.

Achieved results and quantification of project outputs: In the print and online media, we promoted the topic with 7 newspaper comments. In addition, we issued 11 press releases, which were subsequently taken over by other media or agencies. We regularly posted posts related to the topic of renewable resources on social networks for the duration of the project, and a week before the all-day information and entertainment event for the public, we promoted the event on Facebook in the form of paid online advertising. For the purposes of the information and educational event, we created a special subpage and achieved 55,000 unique visits.

- ***CI2 - Myths and mistakes - untruths and misinformation in the field of adaptation and mitigation measures***

The objectives of the "Myths and Mistakes" project were to a) Educate public administration representatives on climate change issues at the local level; b) Raise awareness of appropriate adaptation and mitigation measures at the local level and dispel misinformation in their implementation; and c) Respond to frequent and deliberate recurring myths and untruths in tackling climate change, through accurate, scientifically based, correctly interpreted and comprehensible information. The course of the project consisted of two activities, the first focused more on public administration and the second on the public. The first activity organized a three-day workshop focused on sharing information on adaptation and mitigation of the urban environment with a specific focus on climate change, environmental vulnerability assessment, climate strategy development, energy management, green roofs, microadaptation or electromobility and the use of photovoltaic panels (15 participants). Furthermore, an e-learning course "Cities and Climate Change" was prepared and a handbook was issued: CITIES AND RESIDENTIAL LANDSCAPE OF THE CZECH REPUBLIC AT THE TIME OF CLIMATE CHANGE. A brief overview of the issue for public administration representatives. The second activity focused on preparing and, in particular, sharing information on climate change myths and misinformation. The website https://klimasemeni.cz/myty-o-klimatu/ was prepared, on which the basic information was published. Furthermore, infographics were prepared and published, and last but not least, information was actively disseminated through social networks, information articles, lectures and discussions.

- ***CI2 - Offset projects: A tool to reduce greenhouse gas emissions and increase land resilience***

The aim of the project was to develop information and technical tools to support and implement carbon footprint compensation (US) and the implementation of offset projects (OP). In the first phase, it was necessary to unify the methodology for the implementation of the OP and anchor it in the conditions of the Czech Republic. A literary search of foreign and domestic experience was created. The research served as a basis for the publication: Carbon footprint compensation smartly. Offset of greenhouse gas emissions in the Czech Republic. For the first time in the Czech Republic, the publication approaches the issue of OP and GHG emissions compensation. The electronic publication can be downloaded from the CI2 website, which was presented on social networks and actively disseminated to users. The second phase dealt with the creation of an offset portal (www.offsetujemeco2.cz). The portal enables: redirection to US calculation, calculation of US action - new functionality, OP management, OP payment through the payment gateway, management of all payments and generation of proof of payment. Another key line of the project dealt with the popularization and promotion of the project. The following were created: a) articles for the target group in the media, b) Information sheets for companies and municipalities, c) infographics for the target group, animated video spot. The last part of the project focused on a practical solution. One OP was planted: Fruit tree line at Cimbálka in the village of Budiměřice. This project appeared in the program Czechia is changing the climate.

- ***Čmelák - the Society of friends of nature About climate change in the forest and in the wetland***

The main goal of the project was to educate the public about the impact of global climate change and the possibilities of their mitigation and adaptation - through the promotion of examples of good practice. An important element was also the involvement in practical measures directly in the field in the creation, restoration and maintenance of landscape structures that help retain water in the landscape, and in the transformation of monoculture forests. Through project activities, we involved over 1,200 participants in the field, and we exceeded the set goal more than twice. The promotional activities then reached thousands more. During the entire vegetation period of the year, we implemented 32 events for volunteers on a total of 11 plots, which is more than three times the set goal. There were 6 to 106 participants, a total of 762 participants. From May to October, we organized a total of 6 excursions. There were 11 to 71 participants at the events. A total of 160 participants took part. In June, we organized a professional excursion for 24 participants. In May, we held an Open Day in the wetlands. The number of participants is about 300. Throughout the project, we were available to those interested in the project and by phone, in writing and in the field, we provided advice on how to improve the condition of their land with respect to mitigation and adaptation measures.

- **FAIRWOOD** ***Careful forest management as a tool for cities and municipalities to adapt to climate change***

A new Manual for (smaller) city and municipal owners has been created, which provides them with basic information for the transition to nature-friendly forestry (and FSC). An updated

Czech FSC standard with a new FSC pesticide policy was also issued. Both materials are available both online and in a printed version, and the FSC CR National Office (Fairwood, z.s.) records strong interest from the project's target group. As it was not possible to carry out some full-time activities due to the pandemic situation (this applies in particular to seminars and forestry excursions), (especially online) advice to forest managers was also significantly strengthened. Four press releases were also issued, sections of the websites (www.czechfsc.cz and www.fsclesy.cz) were updated, and contributions on the topic of the project were regularly published on social networks. Overall, it can be assessed that the project, despite the complications associated with the pandemic situation, met its objectives (eg, the number of people supported) and managed to inform the target group about the possibilities of nature-friendly forest management and FSC.

- ***Chaloupky p.b.o. and Forest Kindergarten - School forest and forest grief***

The aim of the project was to popularize the concept of school forest throughout the country, which we pilot tested in several locations thanks to the previous year. The project was promoted through the website www.skolniles.cz, through a printed methodology, but mainly through personal contacts at the trade fair of educational programs and at EE&A conferences. Thus, information about the concept reached directly to individual teachers, ecocentre lecturers and coordinators of ecological education. A number of articles have been published, both in printed and electronic form. In addition to the promotion of the school forest, a qualitative research was conducted to find out how deforestation of the landscape and the disruption of forest ecosystems affect the psyche of children in the Vysočina region. In addition, we compared children who perceive the problem subjectively but do not work with the forest in any way, and then children who participate in the school forest project or help plant trees, take care of new forests… A documentary was made, which examines the environmental grief of children in the Vysočina region and shows its forms. It promotes the school forest project and seeks and displays not only negative feelings such as frustration, fear, sadness and anger, but also hope. With the participation of volunteers - schoolchildren - work took place in a model school forest.